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Electric shovel moves to new site in Lake Superior Iron Country

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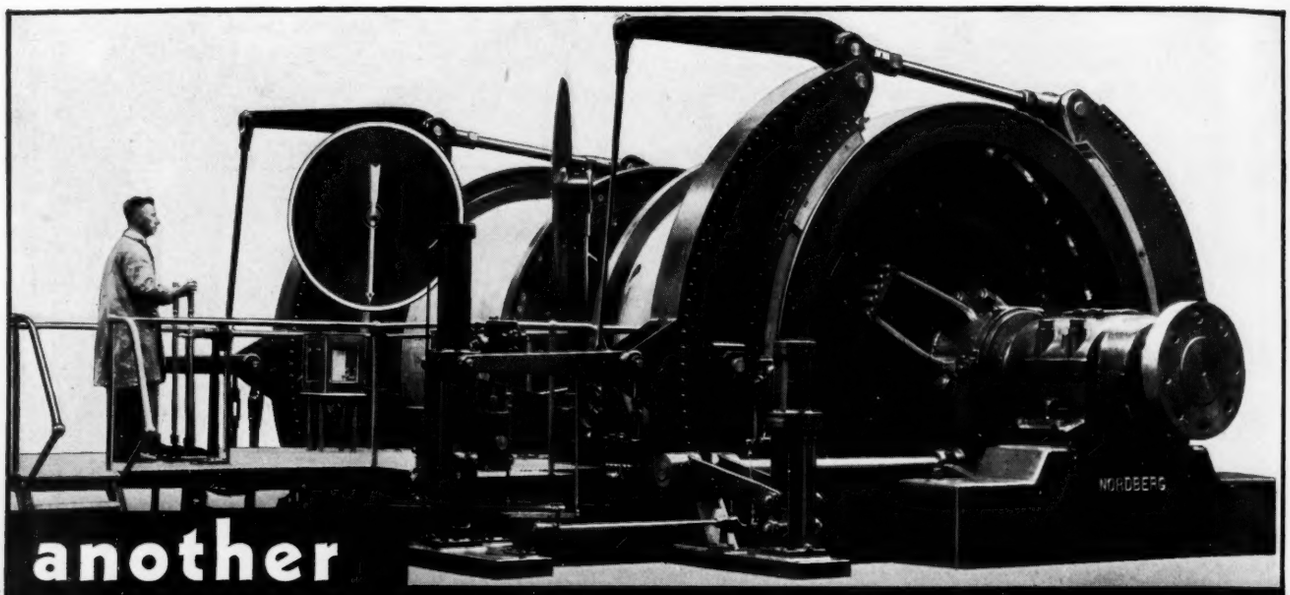

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A. W. ALLEN, *Editor*

Flotation-Cyanidation For Gold-Silver Ores

KEEN INTEREST is being evinced in the opportunity for the application of flotation in the treatment of precious-metal ores, in recognition of the flexibility of its use in respect to class and grade of material treated, as well as in its relation to cyanidation in a composite scheme of metallurgical operations. At Kirkland Lake, Ontario, for example, flotation is being used by Lake Shore Mines to recover gold from cyanide tailing. In Guerrero, Mexico, the Chontalpan y Anexas company treats the ore by flotation, and the tailing by cyanide—as sand and slime, separately. Lake View & Star, and Wiluna, in Western Australia, are handling arsenical ores by flotation, followed by the roasting and cyanidation of the concentrate. In Rhodesia, Sherwood Star is recovering gold from an arsenical ore by the same method; and in the eastern Transvaal an aurocupriferous ore has been found to yield to a straight flotation-cyanidation treatment. In California, amalgamation tailing has been found to respond to flotation, followed by cyanidation of the concentrate. Excellent progress has been made in Russia in the development of a process involving amalgamation, flotation, and the cyaniding of the concentrate.

The center of major interest in the expansion of flotation is in Canada, however. In addition to the development mentioned, at Kirkland Lake, the new plant of McIntyre Porcupine provides an interesting example of the practicability and economy of a change from all-slime cyanidation to concentration by flotation, followed by cyanidation of the concentrate. The immense reserves of cyanide residues at Kirkland Lake belonging to Wright-Hargreaves and Lake Shore will probably be floated by mutual arrangement in a single mill. Beattie Gold Mines is planning to treat its arsenical gold ore by means of a flotation-cyanidation process; and Siscoe Gold Mines, in Quebec, is investigating the possible advantages of flotation, followed by cyanidation, as compared with the process described in a recent issue of this publication.

Each gold ore is a problem unto itself, and disappointment is hazarded if decision as to selection of flowsheet and technique is based solely on a process found successful elsewhere. A complete program of research should precede such decision, for no two ores are exactly alike. The vast amount of material that has been published during the last two decades on individual applications of flotation to almost every type of ore, on the handling of concentrate, its roasting, regrinding, amalgamation, and cyaniding, provides ample data for outlining a plan of metallurgical investigation. As the newer combination process is applied, many examples of specific techniques will become available for guidance, and for the comparison of technical and economic results. Concurrently with descriptive accounts will be released results of the research on fundamental problems in flotation that is essential for economical operation and wider application of the process. Need for new and simpler techniques to meet the problems of treating low-grade and refractory ores should prompt such intensive research, coupled with persistent experimentation and courageous application of steps in metallurgical practice the practicability and value of which have been demonstrated elsewhere.

Prevention Follows Recognition Of Silicosis Hazard

SILICOSIS has appropriately been termed the most insidious disease of the mining industry. It has been responsible for innumerable deaths of general workers, as well as of many in supervisory positions. Efforts to eradicate it have not been effective, despite the conscientious employment of various preventive measures. The seriousness of the malady has long been recognized, especially on the Witwatersrand, where, since 1917, a governmental medical bureau, aided by a law that made compulsory the periodic examinations of miners, has obtained valuable data. Progressive stages of lung infection by silica dust are classified there as: (1) ante-primary silicosis; (2) primary silicosis; (3) secondary silicosis; (4) tuberculosis with silicosis, and (5) simple tuberculosis. Since 1919, victims of the disease in all its stages have been entitled to compensation. A steady decrease in the number of miners afflicted with the disease in any of the forms beyond that of the ante-primary is reported; the number contracting the disease in the initial stage, however, has decreased but slightly, according to government statistics, which indicate that more than two hundred new cases of ante-primary silicosis among European miners have been detected each year since 1919.

In other mineral-producing countries, silicosis, if not as agressively studied and attacked as it has been in South Africa, is receiving increased attention. Four provinces in Canada—Ontario, Quebec, Alberta, Saskatchewan—have recognized it as involving employer liability. Similar recognition is accorded in Great Britain, Mexico, Sweden, and Germany. In the United States, three states—Massachusetts, Wisconsin, Connecticut—grant compensation awards to silicosis victims. Agitation, with similar compensation for silicotic workers as its objective, has recently had the attention of legislative bodies in several other states, principally those in New York and New

Jersey. Effort in the same direction may logically be expected to assume nation-wide proportions within a few years.

A review of the measures adopted in combating silicosis seems to indicate that until collection of the dust that causes the disease is effected at or near its source, and contamination of the air breathed by the worker is thereby prevented, substantial progress in eradicating this industrial health hazard cannot be accomplishd. For this reason the article in this issue by Messrs. Hatch, Fehnel, and Kelley, which describes new types of the Kelley dust trap, recently developed for use with the jackhammer, stoper, and drifter rock drills, is of particular interest. Faster speed in drilling, obtainable by use of the trap, in addition to its value as a means of lowering the incidence of silicosis, should prompt a thorough investigation of the device by the mining industry, especially in those districts where the health of workers has been impaired, and the technical efficiency of operations has been lowered, by the release of silica dust into the atmosphere.

Responsibility for Technologic Unemployment

JOBLESSNESS is increasing throughout the world, especially in those countries that have advanced to a high degree of mechanical civilization. Men and women are turning eagerly to any suggested method ot relief from a condition that is sapping the morale of employed and unemployed alike. In a recent issue of the *Literary Digest* is summarized an article, by Dr. James S. Thomas, of the Commonwealth & Southern Corporation, proclaiming that "Mechanization Creates Employment"; but an impartial examination of Doctor Thomas' thesis will soon dissipate what hopes have been raised by a reading of the title.

The ostrich is credited in the popular mind with burying his head in the sand the better to persuade himself that no storm is raging. Too many publicists insist on repeating the fallacy that the machine effects a "balance" in favor of the employment of human labor. The *Literary Digest,* in giving wide publicity to Doctor Thomas' article, summarizes his conclusions in the following significant statements: "The machine never has been, and is not now, responsible for unemployment. For every man it displaces, it gives employment to more than one." Statistical support for these statements is supplied by the author in the form of tables giving the number of men employed in England—in the textile industry from 1835 to 1914; in the engineering industries, in the publishing business, and in certain grouped trades from 1871 to 1911. A steady increase in the number of workers is recorded, despite the introduction of labor-saving machinery. Doctor Thomas attributes this gain to the displacement of hand labor by machine performance—a conclusion that is open to refutation. The major weakness in his argumentation, however, is indicated in the fact that the statistics used for illustrative purposes are confined to the years prior to the time that unemployment became a serious menace. In company with many another apologist for the machine, he fails to recognize the ultimate effect of its introduction—not merely its immediate effect in a time of steady industrial advance and inventive opportunity—on the demand for labor.

In the socio-economic study to which we have referred, major attention has been paid to industrial developments in England; and the most effective denial of Doctor Thomas' conclusions can be made by quoting the opinions of a distinguished English industrial leader, Lord Melchett, as published in the *Executives Bulletin* late in 1930:

"There are certain factors in economic life today to which we always return and which, if solved, would do much toward the economic stabilization of the world. One is the time factor. Most of us know what is going to happen; most of us can predict fairly well the trend of events. The only question we find very difficult to answer is 'When?' As an illustration, let me point out one curious phenomenon, which is troubling us all over the world. That is the question of unemployment. We have been very rapidly displacing men by improved machinery. And as long as we have enough new work to absorb these men in new enterprises, we do not feel that this phenomenon is taking place. But as soon as that ceases, instead of being on a rising curve, we are on a flat or downward curve, and we suddenly have the phenomenon of several million people for whom we have no jobs."

Technologic change effected by substituting the machine for hand labor may not cause immediate unemployment; but it undoubtedly creates a hazard that has materialized into a serious and menacing problem in recent years, a contributory cause of general depression. No good can come by praising or by damning the machine. It is here—to stay. To compare machine performance with the results of hand labor is as foolish and as futile as to moralize on the distinction between man and one of his simian ancestors.

Doctor Thomas argues in favor of the machine because health standards have been raised and industrial accidents have been lowered in the last half century. But he fails to note that disease and sickness have also been reduced even in greater proportionate degrees in regions where hand labor is employed almost exclusively; that motor-driven vehicles killed 33,500 persons in the United States in 1931, six times as many as in 1913. All such comparisons are pointless and irrelevant, however. The important task is to recognize the incidence of unemployment as an inevitable sequel, though not always the immediate sequel, to the introduction of labor-saving devices, and to act with prescience and humanitarianism in meeting the social and economic problems involved.

No-Accident Records In Mines and Plants

AN INSIGNIFICANT PROPORTION of accidents are caused by influences over which control is impossible, and much harm has been done by repetition of the inane saying that "accidents will happen," which indicates acquiescence in a superstitious belief that events in the physical world are beyond human direction, that logical precaution against hazard may be circumvented by the machinations of some unseen power. Such an attitude is rarely successful in hiding evidence

of failure to think before taking action, or zealously to finish the task in hand.

The first step in rational education in safety matters is to insist that less attention be paid to the effect of chance and more to the cultivation of foresight, thoroughness, care. A few years ago, fire and flood and poison were the masters of man; they are now his servants. Advance in accident prevention will be made in proportion to the degree to which the fact is recognized and acted upon that man holds the power to progress toward or to recede from an ideal of freedom from accident. The establishment of such a goal is important. A decade or less ago the opinion was generally held that accidents, like the poor, must always be with us. Freedom from hazard was considered impracticable of achievement; so the safety-first movement was accorded no more than a half-hearted cooperation by those in a position to foster it. This attitude has gradually changed as facts and figures have demonstrated that wisdom and common sense, humanity and good business, can be applied most effectively through the work of the safety engineer, in the attainment of creditable no-accident performance records.

Remarkable results attained by company-members of the Portland Cement Association were recorded last year, indicating that achievement in accident avoidance could surpass the most optimistic expectation or forecast. The seemingly impossible ideal has been attained; the race has entered its second stage, in which contestants are making every effort to lengthen their records of work without accident. Proof of success in preventing suffering and misery, financial loss and industrial disorganization, is furnished by a recent announcement in the *Explosives Engineer* of the results of a safety competition conducted recently by the United States Bureau of Mines, participated in by 350 companies operating mines and quarries in the United States. A salt mine in New York State, operated by the Retsof Mining Company, takes first place among underground operations, with a record of 354,172 man-hours without an accident. Long may the company preserve and augment such a fine performance! Among surface mines and quarries, the Mahoning open-pit property of the Mahoning Ore & Steel Company, Hibbing, Minn., reported 339,722 man-hours without accident. The record among underground metal mines in safety results was adjudged to have been made by employees at the Harold iron-ore property of the Hanna Ore Mining Company, operating at Carson Lake, Minn., with 196,315 man-hours.

The time is not far distant when a mine will be classified into one of two groups—among those at which accidents occur and those at which a no-accident record is proudly maintained. As the distinction is recognized, and the practicability of human control and direction admitted, directors and executives will have their attention forcibly drawn to the conditions that invite industrial hazards. Such conditions include (1) unsafe working places; (2) defective equipment; (3) inadequate lighting; (4) overheated and stagnant air, sometimes laden with dust. When any or some or all of such conditions prevail, the hazard is accentuated by a mental condition among employees that engenders slow decision and faulty judgment. Much has been done in recent years to reduce hazards, but much remains to be done in emulation of the fine no-accident records being made. Industry should be grateful to the *Explosives Engineer* for sponsoring the competition mentioned, and for providing the trophies. Such initiative, like the happening of the untoward, is not fortuitous.

Credit is also due, for the success of the campaign for the abolition of accidents, to the National Safety Council, responsible for educational and propagandist effort and the compilation of statistics. A recent report discloses that the best no-accident record in a metallurgical plant during 1931 was secured by Metal & Thermit Corporation, of South San Francisco, California, with a total of 180,000 man-hours. Employees at the American Metal plant at Terrero, N. M., also made an excellent showing, with 175,000 man-hours without a lost-time injury. Such figures indicate that, even in the operation of a complicated surface plant, consisting to a large extent of machinery in motion, education and cooperation in the prevention of hazard are achieving results that will exert a highly favorable influence on employee morale and company progress.

Mill Equipment Transport Effected by Airplane

DREDGES have been freighted by air in New Guinea, but the plane has not been used in comparable service elsewhere until recently, when a small mill, with the exception of boilers and engine, was transported by seaplane to the property of Gem Lake Mines, Ltd., in central Manitoba.

The mine is about sixty miles from the railroad, and freighting by tractor or team is possible only during the winter months. Late in the summer of 1931 the company decided to install a small amalgamation plant. Machinery was ordered, and began to arrive at Lac du Bonnet, the rail terminal, toward the end of October. The total weight was about fifteen tons, consisting chiefly of a ball mill, crusher, amalgamation plates, clean-up barrel, steel grinding balls, pulleys, and belting. No piece of equipment could, of course, be heavier or bulkier than the airplane could accommodate; and this necessitated cutting the shell and gearing of the ball mill into three segments.

Two seaplanes, a Fokker Universal and a Fokker Super-Universal, began moving the equipment on October 28, 1931. Landings were made on a lake about half a mile from the mine. As many as four round trips per plane were made in a day. By November 10 the material was on the ground. Earlier completion of the work would have been possible if all the equipment had arrived in Lac du Bonnet in one shipment. Mill construction, begun while freighting was still in progress, was completed on November 11. Operation of the plant started that night. In a few days twelve tons per twenty-four hours was being milled. Ordinary methods of transportation would have been cheaper, but the time saved by airplane transport more than justified the greater expense involved.

The aforesaid economies effected by the application of the airplane for freight-carrying purposes are indicative of the benefits being derived by the mining industry in many parts of the world by the use of this method of transport. Its constant growth may be expected, as well as a close investigation on the part of mining executives of its expanding possibilities, attributable to the steady advances that are being made in the technical and commercial phases of aviation.

Combating the Silicosis Hazard in Rock Drilling

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SILICOSIS, a disease of the lungs among workers in the so-called dusty trades, is caused by the inhalation of fine dust containing free silica. The relation between the disease and the condition to which the worker is exposed may be summarized as follows: The hazard to health increases with the silica content of the dust and with its concentration in the atmosphere. Extent of lung damage decreases with an increase in the size of the dust particles; particles above 10 microns in diameter appear to be inocuous. Injury is progressive in nature, increasing with the length of the exposure, and even continuing after the victim has left the dusty trade. Silicosis is generally followed by tuberculosis of a fatal type.

The disease has been known as a definite industrial hazard for many years. It was first recognized among miners; and, although its presence has been demonstrated among the workers in many other industries, mining still provides the greatest number of victims. The reason for this is because many ores are deposited in quartz-bearing rock, and drilling and blasting in underground, confined spaces produce extremely high concentrations of dust.

The first systematic study of silicosis among miners was undertaken in South Africa in 1902. A preliminary survey in metal mines in the United States was made in 1913, since when many studies have been undertaken by the U. S. Bureau of Mines and the U. S. Public Health Service, resulting in marked improvement in the conditions.

Dust is produced during mining operations from drilling, blasting, mucking, and loading and unloading ore cars. Dry drilling produces the most dust, but it is by no means the only source. A complete program of control of the dust hazard must also take into consideration blasting and the various processes of ore handling. Prevention of silicosis means prevention of the inhalation of silica-bearing dust in dangerous quantities. This may be accomplished by the use of efficient masks; but because of the discomfort caused, workers will not wear them regularly, and so their value is seriously impaired. Removal of the dust at its source, however, offers positive means of control.

The amount of dust produced by blasting and ore handling may be reduced considerably by the use of water applied to the walls and roof in the neighborhood of the heading, as well as to the muck pile, and in the form of a spray during blasting. Wet drilling is also employed as a means of reducing dust pollution from rock drilling. In the light of present knowledge concerning permissible dust concentrations, and with improved technic of dust sampling and counting, however, these wet methods have been shown to fail in giving the degree of protection required. Widespread use of water in deep and hot mines is also objectionable on account of the increased humidity resulting. The dust concentration must therefore be reduced further by general ventilation, which, when properly applied, serves to dilute the dust-polluted air. The ventilating system must be carefully designed and carefully operated.

Dust produced by rock drills is local, which suggests the use of local exhaust hoods, employed so widely in other dusty industries for control purposes. Of interest to note in this connection is that 35 types of exhaust hood were proposed in 1902 during a competition in South Africa; and in the United States a score or more apparatus patents have been granted. Use of such devices in the past, however, has proved unsuccessful not because the principle is wrong, but on account of such factors as faulty hood design, lack of sufficient air flow, and the use of improper dust-collecting equipment.

An exhaust hood, known as the Kelley trap, has been developed recently, however, in which these faults were corrected so far as possible. Its use has been shown to reduce the dust concentration associated with rock drilling below the hygenic safe limit. Unlike many earlier devices, no attempt is made to secure a tight seal between the hood and the drill steel and at the rock surface; nor is the exhaust air from the drill employed to actuate an ejector as a source of suction. The trap is connected to a separate exhaust system provided with a suction fan and a dust-collecting plant of adequate capacity. For use in connection with a drill of the Jackhamer type, the trap consists of a sturdy metal chamber shaped like an inverted dipper, and provided with a side outlet through which it is connected to the exhaust system as shown in Fig. 1. The trap is split and hinged to facilitate inserting and removing the drill steel, which passes loosely through a hole in the top. Dust is prevented from escaping by the inrush of air at the openings. An inner jacket concentrates the exhaust stream of air at the point where the dust emerges from the hole, and thus captures it. The device is not attached to the drill, but is operated as a separate piece of equipment.

The hood for a drifter, of reinforced rubber, is split longitudinally to permit rapid changing of the drill steel. Reduced diameter at the open end (see Fig. 2) permits close adjustment of the hood to the rock surface, regardless of the contour of the latter. Inasmuch as the drifter is operated at angles above and below the horizontal, the hood must be secured in place during drilling. This is effected by means of an adjustable support so attached to the drill shell that the hood always occupies the same position relative to the drill, no matter what may be the angle of the latter. The support, illustrated in Fig. 2, has an axial movement of 17 in., which permits satisfactory adjustment of the hood to the rock face.

Fig. 1.—Kelley dust trap, Jackhamer type

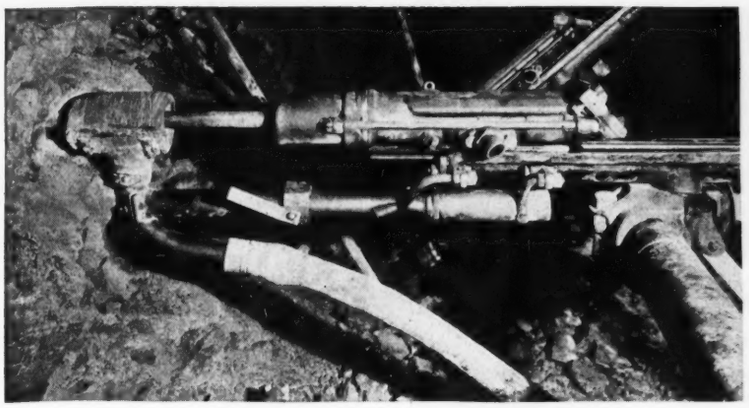

Fig. 2.—Trap and mounting for drifter

The section of the mine in which our tests were made was closed off by means of canvas brattices, to prevent the influence of general mine ventilation on the results. An Ingersoll-Rand N-75 drifter was used throughout. It was tested in three positions: 45 deg. down, horizontal, and up, 0 to 45 deg. from the vertical, except in the case of the South African "dustless" drill, which was operated only in the horizontal and vertical positions. The dry drill was equipped with a blower tube during the tests on the horizontal and down drilling; and a solid starting steel was employed to avoid the violent scattering of dust by the air blast through the hollow steel during the collaring of holes. Re-

In the Stopehamer assembly, designed for drilling vertically up or at small angles from the vertical, the drill is supported by a pneumatic column, which exerts a constant upward pressure and thus forces the drill progressively toward the rock as the hole is drilled. The hood support, of adjustable length, is provided by an auxiliary pneumatic column (Fig. 3). Its lower end is secured to the toe of the main pneumatic column, and it is held in a position parallel to the axis of the drill by two clamps, attached to the latter, which travel along the auxiliary column as the drill progresses. The hood is forced up against the rock when the compressed air is applied, and drops of its own weight when pressure is released. In addition to supporting the hood, this device also serves to keep the drill in place while changing steel, thus reducing the time required for this operation. Of heavy molded-rubber construction, the hood has a steel reinforcing ring that provides attachment to the supporting rod. The whole supporting assembly weighs less than 30 lb.

The traps described were not designed to form a complete inclosure at the point of dust generation. Dust is prevented from escaping through the openings, however, by the inrush of air; and, for a given drilling operation and type of hood, therefore, a minimum rate of air flow is necessary to produce the velocities required to keep dust concentration, at the breathing level of the operator, below the hygienic safe limit. The object in the development of these hoods was to accomplish this result with the lowest possible rate of air flow, and hence with minimum power consumption.

Limiting dust concentration for safe exposuure to rock dust varies with the silica content of the rock. It has been established at from 5 to 20 million particles per cubic foot of air for dusts ranging from 80 to 90 down to 30 to 40 per cent free silica. In our tests, a standard of permissible dust concentration of 5 to 10 million particles per cubic foot of air, determined by the Greenburg-Smith impinger, was taken as the criterion of satisfactory dust collection. Tests with the Jackhamer type of drill have been described elsewhere.[1] A summary, presented in Table I, shows concentrations ranging from slightly over 5 million particles down to 1 million per cubic foot of air.

The efficiency of the exhaust hood employed with the drifter was investigated in the experimental mine of the Ingersoll-Rand Company, at Phillipsburg, N. J. These investigations were undertaken as part of a cooperative study conducted by the New York Department of Labor, Metropolitan Life Insurance Company, Harvard School of Public Health, and the George J. Atwell Foundation Corporation. The kindness of the Ingersoll-Rand Company in making available the company's experimental mine and equipment, and the assistance and advice of its staff, are gratefully acknowledged. While making this study we had opportunity to compare this method of control with the wet methods employed in the domestic and South African types of wet drills. Comparative data on drilling speeds associated with these three methods of control were also obtained.

Table I—Dust Concentration With Jackhamer and Trap in Operation

Drill	Average Drilling Rate, Feet per Hour	Dust Concentration, Million Particles per Cubic Foot
BCR-430	13	1.84
BCR-430	23	2.6
S-49	16	1.07
S-49	22	1.80
X-59	15	4.35
X-59	11	3.9
3:BCR-43	..	....
4:S-49	..	5.6 (a)

(a) Seven drills set up in circle 6 ft. in diameter; sample taken in center.

Table II—Comparison Between Dry Drilling With Trap and Wet Drills

Method of Dust Control	Dust Concentration, Million Particles per Cubic Foot: 45 Deg. Down	Horizontal	0 to 45 Deg. From Vertical	Average	Average Rate of Drilling, Feet per Hour
Dry drilling with trap	5.7	7.1	11.6	8.1	38.6
South African wet drill	....	27.5	6.8	17.1	30.7
American wet drill	18.7	15.2	11.2	15.0	35.7

Fig. 3.—Kelley trap and auxiliary pneumatic support for Stopehamer. Drill is supported in place while changing drill steel

[1] "Control of the Silicosis Hazard in the Hard Rock Industries—II." An Investigation of the Kelley Dust Trap for Use With Pneumatic Rock Drills of the Jackhamer Type. T. Hatch, G. S. Kelley, and J. W. Fehnel, *Jour. Ind. Hyg.*, Feb., 1932, Vol. 14, p. 69.

sults of the tests, including the average over-all rates of drilling obtained with each type of drill, are summarized in Table II.

In the tests with the dry drill employing an exhaust hood, the dust concentration was reduced below 10 million particles per cubic foot of air when operating in the horizontal and down-drilling position. In the stoping position the results were not entirely satisfactory; but improvements in the design of the hood since these tests were made have increased its efficiency in this position so that dust concentrations below the hygienic safe limit may be expected. Moreover, the Stopehamer ordinarily used in vertical up drilling is a smaller machine, and has a lower rate of dust production than has the drifter, and the efficiency of dust collection with it will therefore be higher. Dust concentrations as low as 2.8 million have been obtained with this apparatus when drilling a high-silica rock.

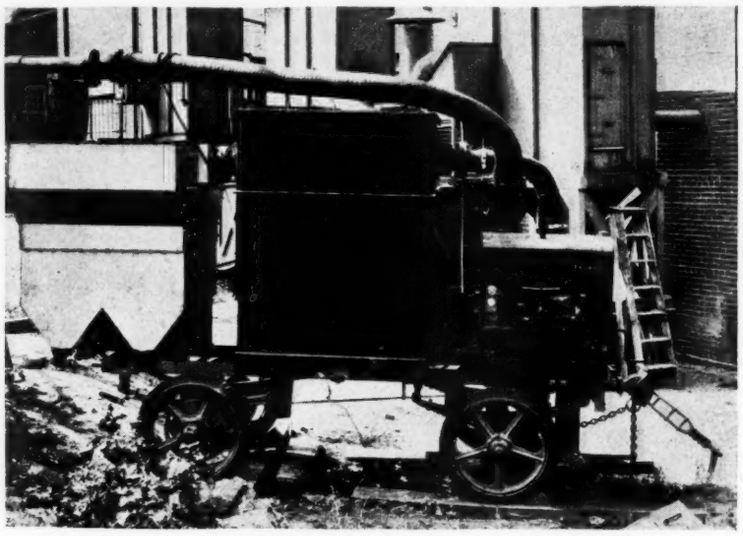

Fig. 4.—Portable dust-removal plant with capacity of five drifters or twelve Jackhamers. The dust in the air discharged by this machine is well below the hygienic safe limit.

Dust concentrations developed during wet drilling, using the domestic wet drill and the South African "dustless" drill, were higher than those associated with the blower-type drill equipped with the exhaust hood (see Table III). Individual tests also showed a much greater variation in concentration, particularly when trouble was experienced with sticking of the drill steel. The process of "blowing out" resorted to under such circumstances was accompanied by the escape of considerbale quantities of dust, with rapid increase in concentration in the general mine air as well as at the heading. Of interest to note is that during the routine operation of the wet drills, dust concentration in the general mine air increased more rapidly than with dry drilling. An outward flow of air from the heading during wet drilling may have occurred, whereas the exhaust hood produces an inward flow which serves to keep the dust from escaping into the general mine atmosphere. Smoke tests at the canvas brattices proved this reversal of leakage. It was also caused in part by the lower efficiency of dust control by wet methods.

The mine is in a limestone formation, and the results obtained with the wet drills cannot therefore be used to predict the dust-collecting efficiency of wet drilling in a high-silica rock; the dust produced by the latter is known to be less easily wetted than is limestone dust. On the other hand, the efficiency of collection by the Kelley trap does not vary materially with the physical properties of the dust.

Use of the Kelley trap protects the operators against silicosis, improves the general working conditions, and raises productivity, by increased visibility, the elimination of water and mud, and an increase in the speed of drilling. In the operation of the Jackhamer, the drilling speed was increased 21 and 11 per cent for applied loads of 20 and 40 lb., respectively. Results were obtained with a testing tripod and weights, in order to avoid the variation in load when pressure is applied by an operator.

Actual drilling speeds and over-all rates of drilling obtained with the drifter, employing the three methods of dust control, are presented in Table III. For all positions, the results indicate an average increase in actual drilling speed of about 40 per cent, and a 22 per cent increase in the over-all rate for the blower-type drill with exhaust hood, compared with the domestic and South African wet drills. The over-all rates for the dry drill obtained during the dust-control tests (see Table II) show an increase of 8 per cent over the domestic wet drill, and 26 per cent over the South African wet drill.

The higher drilling speed observed while dry drilling with exhaust hood in operation is the result of a continuous removal of cuttings from the hole. This reduces the cushioning effect on the cutting bit, and also makes possible the more rapid change of steel, because the hole is kept clean. In our tests we were able to drop the drill steel to the hard bottom of a 45-deg. down hole, 10 ft. deep, without the usual blowing out. In spite of these considerations, however, more data under actual working conditions will be necessary before definite conclusions can be reached regarding comparative drilling speeds.

Design of the exhaust system and dust-disposal plant for use with the Kelley trap in underground drilling is governed by the mine layout, its depth and the concentration of mining operations. Essential parts include the traps, a system of suction hose and piping, the dust-collecting plant, and an exhaust fan. Actual plant layout depends on the location of the dust-collecting equipment and suction fan with reference to the drilling operations. It must be flexible in design, to accommodate itself to changing working conditions. In highly scattered operations economy may dictate provision of individual collectors for each drill, although the most satisfactory result will be obtained with a central plant under the charge of one operator.

Design of the dust-collecting plant depends primarily on the efficiency of removal required, which in turn is determined by the nature of the dust (its silica content) and the location of the point of discharge. If the collector is above ground, or exits into an uptake shaft, a higher dust concentration will be permitted in the discharged air than would be allowed in a plant that simply recirculates the air underground. In the latter, the concentration of dust escaping from the collector must be below the hygienic safe limit.

In general, the collector effects a

Table III—Speed of Drilling

Methods of Dust Control	Position	Feet Drilled	Time, Minutes Actual	Time, Minutes Over-all	Drilling Speed—Actual, Inches per Minute	Drilling Speed—Over-all Feet per Hour
South African wet drill	45 deg. down	16	11.8	27	16.3	35.5
	Horizontal	18	14.1	30	15.3	35.5
	45 deg up	18	12.3	26	17.5	41.5
	Total and average	52	38.2	83	16.4	37.5
American wet drill	45 deg. down	18	13.4	34	16.3	32.3
	Horizontal	18	12.4	27	17.2	39.6
	45 deg. up	17	11.2	25	18.2	40.8
	Total and average	53	37.0	86	17.2	37.0
Dry drilling with exhaust	45 deg. down	18	8.5	24	25.1	45.0
	Horizontal	18	8.9	23	24.0	46.2
Blower tube and horizontal position	45 deg. up	18	9.5	24	22.8	44.4
	Total and average	54	26.9	71	24.0	45.0

preliminary separation for the removal of the large particles, followed by treatment for the removal of the fine and hygienically dangerous material. Various separators of the so-called inertial type can be used for the primary stage; but, owing to the fineness of the dust to be removed, the second stage requires the use of fabric filters. Choice of fabric and the rate of filtration depend on the nature of the dust to be removed, but more particularly on the dust loading, which, for satisfactory operation, should be kept low. Hence, the efficiency of removal in the preliminary chamber must be as high as possible.

Dust produced from a hole of 2 in. diameter amounts to 0.0218 cu.ft. per foot drilled, or 3.27 lb. for rock weighing 150 lb. per cubic foot. Thus, at a drilling rate of 100 ft. a day, more than 1½ tons of dust will be collected from ten drills in eight hours. The dust-removal plant should have storage space for at least one-half of this amount, so as to limit the frequency of unloading to twice a day. The dust must be removed and disposed of in a safe manner.

Collectors of the required efficiency and capacity can be designed to meet the needs of any given installation. As an illustration, the portable unit, including suction fan, motor, and dust-removal plant on a single mounting shown in Fig. 4, has a capacity of five drifters or twelve Jackhamers. On an open excavation, we have operated a plant with a capacity of 40 to 50 Jackhamers, which collected as much as four tons of dust a day. The added cost of dust-control equipment was only 1.05 per cent per cubic yard of rock removed.

■ ■ ■

Electric Operation of Rope Tramways

R. F. Emerson

Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

ROPE TRAMWAYS are of the carrier or the reversible type. The latter may use one bucket, which is hauled out, dumped, and then returned to the loading station; or it may have two buckets, one of which returns empty when a full bucket is hauled out. Figs. 1 and 2 show reversible tramways. The continuous-carrier type is usually employed in mining service where distances are fairly long and a considerable tonnage must be transported. Rope tramways are in successful operation carrying from a few tons to several hundred tons per hour, and in length from several hundred feet to several miles. Continuous running tramways are not limited in length by the strength of the tramway rope; the tramway can be operated in two or more sections, each having its own drive. It can be designed so that the track cables are continuous and allow the carriers to pass from one section to the other without interruption. Fig. 3 shows a tramway for carrying ore, of the continuous running type, which discharges automatically into a bin as the buckets pass around a large-diameter tail sheave.

Induction motors are generally used for operating tramways, because alternating current is almost universally available. Fig. 4 shows a 60-h.p., a.c. motor equipped with a solenoid brake. It is directly connected through herringbone gear reducer to a 60-ft. diameter grip sheave, which handles a 1-in. diameter rope of plow steel, mounted on the slow-speed shaft of the reducer. The toggle jaws in the grip sheave are heat-treated castings. Two emergency hand-operated brakes are mounted on the grip sheave.

With the wound-rotor type of induction motor, smooth starting may be obtained without slippage of the traction rope, if the resistor in the secondary of the motor has been properly designed. To run at an almost constant speed under varying conditions of load is also possible. The load may vary from a high positive load, requiring the full-load rating of the motor, to an "overhauling" load.

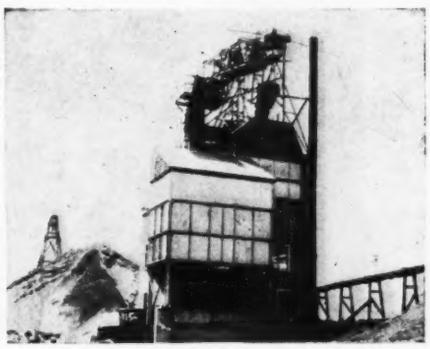

Fig. 1—Storage hopper of single reversible tramway driven by a 25-hp. motor; capacity, 25 tons per hour.

Fig. 2—Double reversible tramway with two buckets traveling back and forth at 650 f.p.m., each on its own track cable driven by a 50-hp. wound-rotor induction motor; capacity, 37.5 to 55 tons per hour.

Occasionally the mine is above the mill, so that the ore is transported down a grade sufficiently steep to "overhaul" the motor. Under such conditions of operation the following characteristics of the induction motor should be noted: The motor will act as a brake and hold back the load, thus preventing overspeeding; it will regenerate up to its full-load capacity with only about 3 to 5 per cent increase in speed above its no-load speed. On a tramway of this kind, the motor will take power from the line to start the equipment, particularly if the tramway buckets are empty. As the buckets fill with ore, the load is taken from the motor, and the motor starts to regenerate current back into the electric supply line. The statement that the motor will not overspeed when working on an overhauling load assumes that the motor rings have been short circuited. If resistance is left in the motor secondary, as, for example, if the controller is left on one of the intermediate points, the motor will accelerate. This contingency can be guarded against by the use of a relay and a contactor, so arranged that on reversal of current the relay operates and closes the contactor, which short circuits the motor rings and thus insures absence of resistance in the motor secondary when the load starts to "overhaul" the motor. If the motor regenerates current into the electric supply line, load elsewhere must be provided on the electric line to absorb this regenerated power. A motor for a

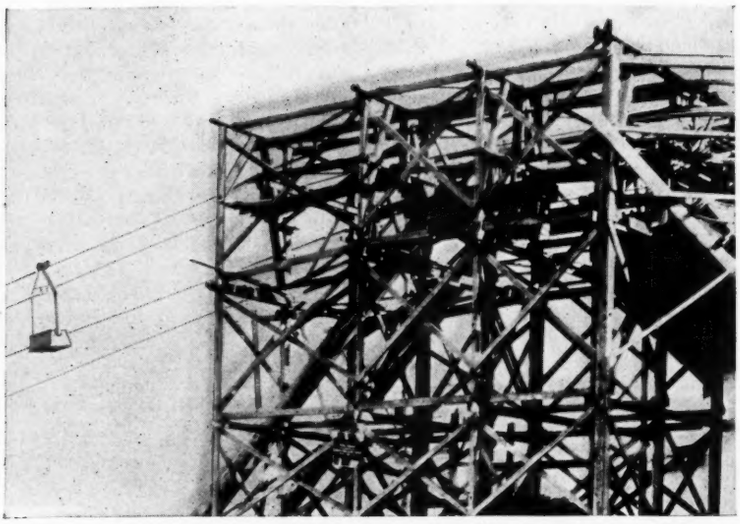

Fig. 3—Ore-carrying tramway having a capacity of 50 tons per hour and driven by a 15-hp. wound-rotor induction motor. The buckets travel at 500 f.p.m. and discharge automatically into a bin as they travel around a large-diameter tail sheave.

tramway operating on "overhauling" load should be equipped with a spring-set brake. If the power fails, the brake immediately sets and stops the tramway.

Accuracy in stopping a rope tramway is sometimes essential, particularly if the bucket must be brought under a loading spout. In such cases the control equipment will be interlocked with that of the motor driving the feeder conveyor, which will start as soon as a tramway bucket has come to rest under the spout, and must be shut down when the bucket is full. To insure an accurate stop, speed of the tramway must sometimes be reduced 50 per cent or less before cutting off power and setting the brake. Otherwise the bucket may stop short of the required spot, or coast too far. A convenient method of securing a slowdown preliminary to the final stop is to insert resistance in the motor secondary, then cut off power and set the brake after the speed has been reduced. Best results from this method of operation are obtained when load on motor is about full-load motor rating or even more. If the load is very light, to insert resistance in the secondary will have little effect unless a large block of resistance is introduced. Also, if the load is "overhauling" the motor, to insert resistance in the motor secondary has the opposite effect; it would cause the motor to speed up. If the load is "overhauling" in character, an artificial load is sometimes introduced by allowing a limit switch to operate that simultaneously sets the motor brake and cuts in a block of resistance for a few seconds. Power is then cut off when the speed is reduced sufficiently. The brake is already set when power is cut off from the motor, which insures accuracy in stopping. Another way to obtain a low speed or a creeping speed with an "overhauling" load is to open the power supply to the motor and excite the alternating-current stator winding from a direct-current source of supply. The speed obtained depends on the resistance in the secondary circuit, the torque applied to the motor, and the amount of direct-current excitation. The disadvantage of this method is that a special low voltage is usually required, sometimes as low as 10 or 15 volts. This method of obtaining a slow speed is used for unbalanced slope mine hoists where normal speed is high and where lowering is at less than normal speed, to conserve the mechanical brakes. Similar control can be used with rope tramways if the requirements of the creeping speed warrant the additional complication of a special source of direct current and the additional control equipment required.

The rope tramway is being used where material must be carried a considerable distance, particularly where the contour of the ground would forbid the construction of road or laying of tracks: such as shown in Fig. 5. Undoubtedly the best rope tramways were

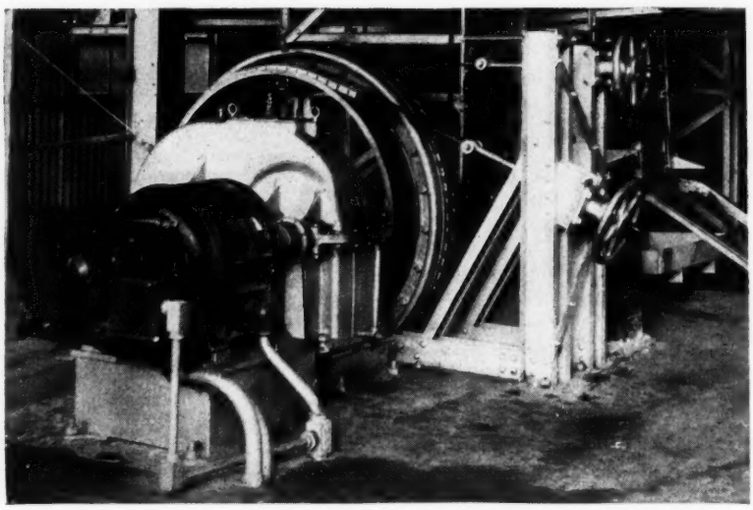

Fig. 4—A 50-hp. wound-rotor induction motor connected through herringbone-gear speed reducer to a 6-ft. diameter grip sheave

Fig. 5—Bleichert bicable tramway with buckets discharging from the cable while in motion. Buckets pass around a tail sheave automatically and return to the loading terminal to be reloaded; capacity, 60 tons per hour; speed 450 f.p.m.; tramway is operated by a 30-hp., 900 r.p.m. wound-rotor induction motor.

Fig. 6—Bleichert bicable tramway carrying 150 tons per hour of crusher rock a distance of 10,125 ft.; driven by 50-hp. wound-rotor induction motor with adjustable speed control.

installed where the ground was so rugged that any other type of transportation was out of the question. Since their adoption this method has been found to have many advantages, even in locations that would permit the use of other methods of handling material. These advantages include low cost of operation and greater freedom from right-of-way difficulties; the towers supporting the cable can be spaced so that the cables will bridge over roads, railways or buildings. Fig. 6 shows a Bleichert bicable system tramway carrying 150 tons of material hourly and which does not interfere with agricultural operations where the tramway passes over farming country. The photographs are reproduced by the courtesy of the American Steel & Wire Company, Worcester, Mass.

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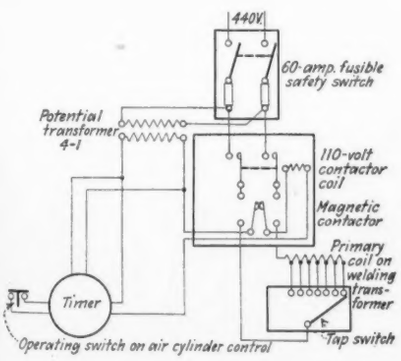
Homemade Spot-Welding Machine

AN AUTOMATIC WELDING MACHINE applicable for welding mine ventilating pipe has been developed at the shops of the Homestake Mining Company, Lead, S. D. A photographic reproduction of the machine, supplied by S. J. Staple, master mechanic, is shown in the accompanying illustration. The sturdy frame, supporting the I-beam boom, the stationary operating table, and the electrical apparatus, consists of a column made of 12-in. channel iron, reinforced with short lengths of 4-in. and 6-in. angle iron. Light strap iron is used for bracing the vertical base, to which is secured the operating mechanism, composed of a small air cylinder and a four-way valve, and the flexible connections leading to the upper electrode clamp. The stationary and the moving electrodes are water-cooled and contain removable copper points. All electrical connections are insulated from the frame by fiber or mica segments. Air and the circuit switches are controlled simultaneously by the specially designed operating lever on the air cylinder valve. The operating switch, shown in the accompanying wiring diagram, cannot be closed until pressure is applied to the welding electrodes. When the switch on the operating lever is closed, the automatic timer applies current to the welding electrodes for 1/20 sec. to 20 sec., depending on the setting of the timer. The machine can be used for welding 3-ft. lengths of No. 20 galvanized iron pipe, 6-in. in diameter and larger.



Wiring diagram for spot-welding machine.

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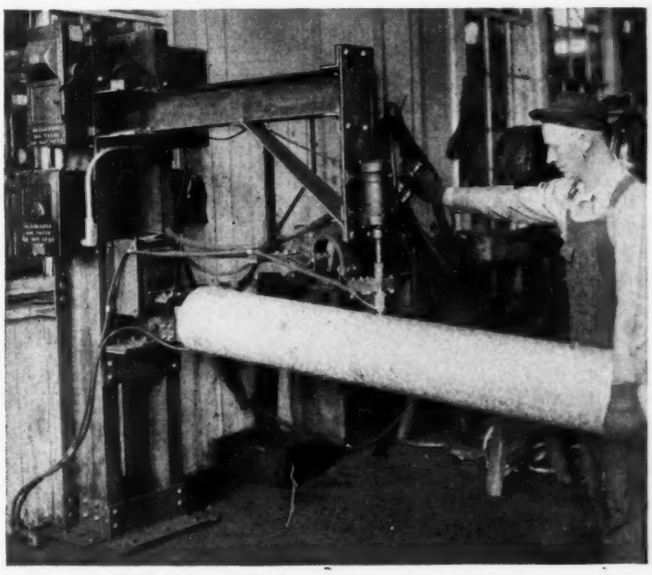
Spot-welding 12-in. galvanized-iron piping, for underground ventilation lines.



Mining and Processing Magnesite

Practice and equipment at the modern crushing and calcining plants of the Sierra Magnesite Company, operating near Gustine, in California.

G. J. Young

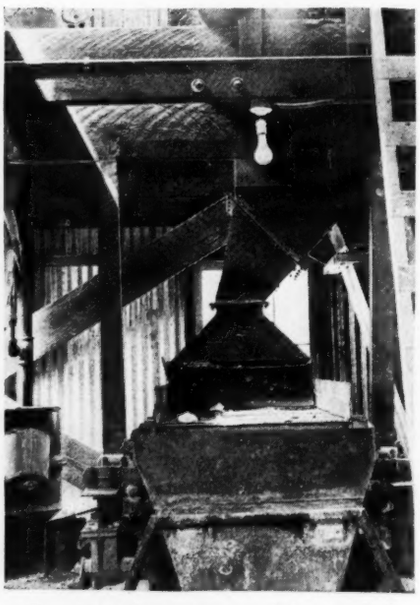
IN THE western foothills of the Coast Range, near Gustine, Calif., and 16 miles west of Ingomar, the Sierra Magnesite Company, Ltd., has opened up a new mine and constructed a crushing and calcining plant. The scale of operations at the plant, which was completed last November, has reached the limits of the present demand for magnesite products. A significant fact in connection with the property is that search for a new magnesite mine was begun several years ago, and that successful opening up of a commercial deposit, and its equipment for production, were effected during a period of economic readjustment. However, Sierra Magnesite, which had operated mines in the vicinity of Porterville, Calif., for a number of years, and established both a plant and practice for the preparation of magnesite, found its mining costs increasing as its near-by deposits were worked out and more distant deposits were opened up. The newer deposits were also small, and, finally, a large deposit favorably situated with reference to haulage and railroad transportation had to be found.

The new mine, called the Bald Eagle, was discovered a number of years ago, and mining was started by the Plastic Magnesite Company, which opened up the magnesite deposit with a 350-ft. tunnel and about 350 ft. of drifts. This was in 1920, when about fifteen men were employed and a daily production of about 30 tons was hauled by truck to Ingomar for shipment. Records of the state mineralogists' office show that 4,064 tons of magnesite was produced in Stanislaus County in 1920.

Recorded production started in 1917 and ceased in 1923, the total being 17,093 tons. Presumably this production came from the Bald Eagle mine. These state reports provided a clew, and officials of Sierra Magnesite visited the property, ultimately deciding to undertake exploration work. After driving about 1,800 ft. of drifts and crosscuts, they became convinced that commercial tonnages were available, and subsequently the property was acquired. Development and exploration were continued, and plans made for mining and the erection of treatment plants. A decision was made to concentrate the company's principal production at this property, and to build a modern treatment plant that would take care of present and future markets. Long experience of the company enabled it to design and construct the new plant and equipment so that minimum costs both for operation and maintenance would be achieved. The new plant is therefore of particular interest.

The magnesite deposit is a blanket vein, irregularly warped, and dipping 10 to 15 deg. to the south. It is in a decomposed serpentine hill on the north side of Quinto Creek and extends into the hill, but apparently it does not outcrop. Adits give access to the deposit. Raises up the dip and drifts along the strike have developed a considerable area of magnesite that ranges from 2½ to 12 ft. in thickness. The immediate hanging wall is a gouge of blue clay. Several levels have been established, and the principal mining consists of driving galleries 8 to 10 ft. wide, up the dip, leaving a small thickness of magnesite in the top for support. These workings will be driven to the upper limits of the blanket formation, and then that part of the deposit which lies between the galleries will be mined by a retreating system.

The principal adit extends under the lowest part of the blanket, which is reached by raises and transfers. Owing to the low angle of dip, transfers are readily driven up to the mining levels, and through these openings the magnesite is loaded by chutes into mine cars on the adit level. As the blanket is not deep, raises are extended through to the surface for ventilation where needed.



Symons rocker screen receiving crushed product from bucket elevator

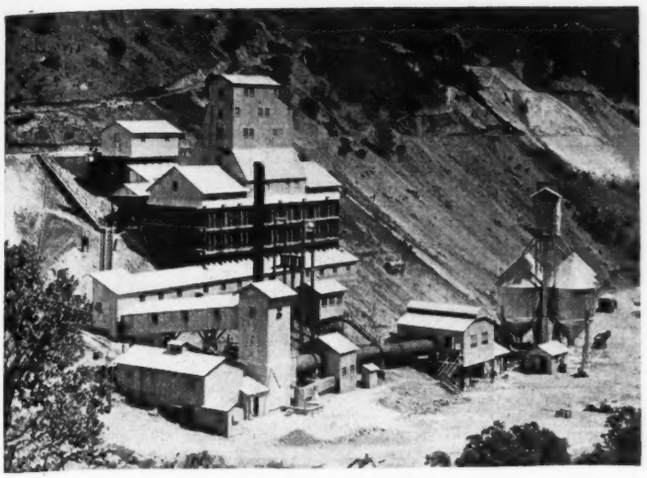
Comparatively little timber is required in mining, and ventilation raises are lightly cribbed. The magnesite is handled by wheelbarrows to the transfers. The formation is easily drilled and blasted. Ingersoll-Rand No. 30 Jackhamers are used, and 6-ft. holes drilled. Operation of four machines yields about 100 tons per shift. Each machine drills three rounds per shift, and only ten to fifteen drill steels are necessary per day. Only two drill changes are required per hole.

A mounted Leyner drill is used in crosscutting and drifting. A small shop on the property is equipped with an improvised drill sharpener that suffices for the needs of the mine. A small Imperial type belt-driven compressor supplies the mine and also the oil burner of the calciner furnace. The mine employs 35 men; five or six are on development, and the remainder on mining, timbering, shop work, and tramming service to the crusher plant.

The magnesite is more or less heterogeneous and varies from a compact pure white, conchoidal fracturing, high-grade mineral to a discolored, granular-appearing mass. Mining is selective. The highest-grade mineral, which occurs in occasional pockets, is sorted out and stacked whenever provision must be made to meet the limited demand for this product. After breaking, the clay and other obvious impurities are culled out so far as practicable, and the remainder is transported to the transfers. Accessory silica is the basis for determining the two principal grades that are kept separate in mining the deposit. Fortunately, the silica occurs only in the cracks and crevices of the magnesite. Water is present in one part of the mine, but the flow is not important.

The receiving bins provide 200 tons of storage space and are divided into three steel-lined compartments. A rail grizzly is above each compartment, and oversize is sledged through. Crude storage facilities are such that the three mine grades may be stored in separate bins. Grade A contains 0.2 per cent silica; Grade B, 1½ to 2 per cent silica; and Grade C, 3½ to 4 per cent silica. About 50 per cent of the mine product is Grade C.

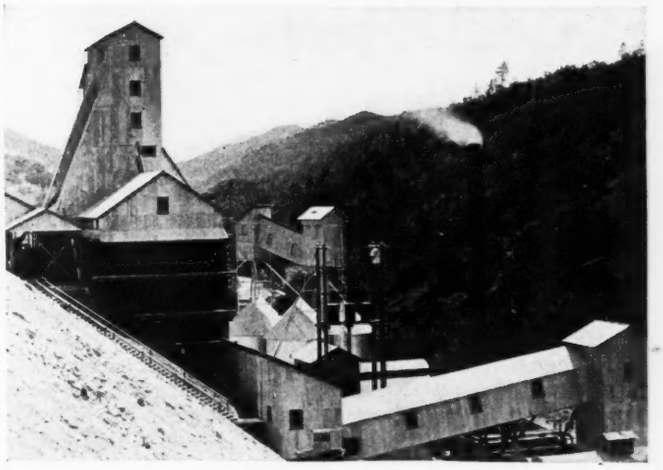
Steel-lined chutes discharge the contents of the receiving bin, as they are required, into a Blake type, 10x20-in. jaw crusher, which delivers a 2- to 2½-



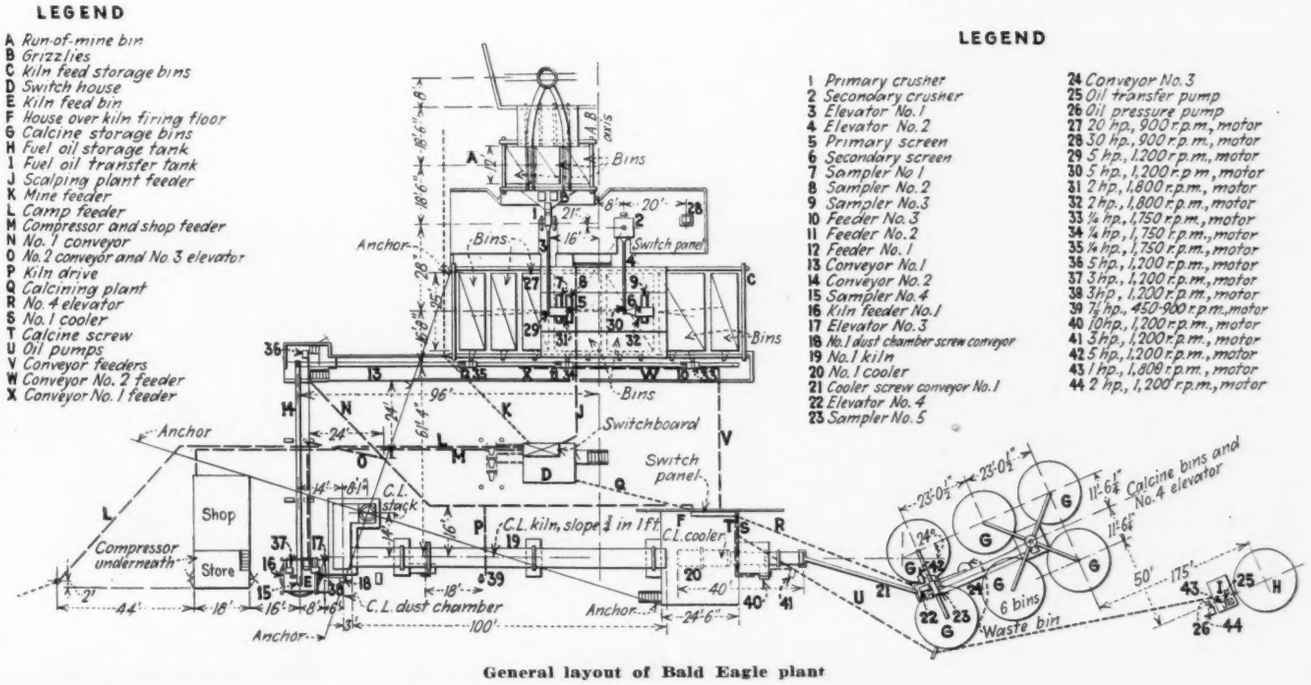
Bald Eagle plant: crushing, cleaning, and calcination units

in. product to a chain-type bucket elevator, equipped with 12x7-in. buckets. This elevator discharges onto a horizontal, double-deck, 3x6-ft. Symons rocker screen. Three products are made: an oversize, plus $\frac{3}{4}$ in., which goes to a secondary, 2-ft., Symons cone crusher, with a $\frac{1}{2}$-in. opening; an intermediate product, minus $\frac{3}{4}$ plus $\frac{1}{8}$ in., which goes to bin No. 3, 4, or 5; and the fines, minus $\frac{1}{8}$ in., which are sent to bin No. 1, 2, or 3. A chain-type bucket elevator, with 8x5-in. buckets, discharges the Symons crusher product onto a secondary single-deck screen of the same size and type as the primary, but with $\frac{1}{2}$-in. openings. Oversize of the screen is returned to the Symons crusher, and the undersize sent to bin No. 4, 5, 6, or 7. Capacity of the crushing and screening plant is 100 tons per shift. Automatic samplers, consisting of a sample bucket supported on sprocket chains that draw it across the flow of material, are placed below the screen floor. Samples taken of each product sent to the crushed-magnesite storage bins are delivered by spouts to a series of closed sample bins in the sampling room. The various products are classified on the basis of their silica content. Screening equipment is sufficiently high above the crushed magnesite bins that all products can be handled by spouts. The spouts are flanged metal pipes.

The crushed-mineral bin, of timber construction, has a capacity of 2,000 tons and is divided into seven compartments. Its total capacity corresponds to about one month's feed for a single rotary kiln. Classification of the crushed product, according to bin numbers, is as follows: No. 1 bin, 10 per cent silica; No. 2, 6 per cent; No. 3, 4.5 per cent; No. 4, 2.5 per cent; No. 5, 1 per cent; No. 6, 0.5 per cent, and No. 7, 0.1 per cent silica. Separation by screening segregates the silica in the fines, and frees the larger sizes of their silica, iron, and alumina content. Some hand picking of high-grade magnesite takes place at the primary screen. Con-



Bald Eagle plant: conveyor runs and screen house over crushed magnesite storage bin


LEGEND
A Run-of-mine bin
B Grizzlies
C Kiln feed storage bins
D Switch house
E Kiln feed bin
F House over kiln firing floor
G Calcine storage bins
H Fuel oil storage tank
I Fuel oil transfer tank
J Scalping plant feeder
K Mine feeder
L Camp feeder
M Compressor and shop feeder
N No. 1 conveyor
O No. 2 conveyor and No. 3 elevator
P Kiln drive
Q Calcining plant
R No. 4 elevator
S No. 1 cooler
T Calcine screw
U Oil pumps
V Conveyor feeders
W Conveyor No. 2 feeder
X Conveyor No. 1 feeder
LEGEND
1 Primary crusher
2 Secondary crusher
3 Elevator No. 1
4 Elevator No. 2
5 Primary screen
6 Secondary screen
7 Sampler No 1
8 Sampler No. 2
9 Sampler No. 3
10 Feeder No. 3
11 Feeder No. 2
12 Feeder No. 1
13 Conveyor No. 1
14 Conveyor No. 2
15 Sampler No. 4
16 Kiln feeder No. 1
17 Elevator No. 3
18 No. 1 dust chamber screw conveyor
19 No. 1 kiln
20 No. 1 cooler
21 Cooler screw conveyor No. 1
22 Elevator No. 4
23 Sampler No. 5
24 Conveyor No. 3
25 Oil transfer pump
26 Oil pressure pump
27 20 hp., 900 r.p.m., motor
28 30 hp., 900 r.p.m., motor
29 5 hp., 1,200 r.p.m., motor
30 5 hp., 1,200 r.p.m., motor
31 2 hp., 1,800 r.p.m., motor
32 2 hp., 1,800 r.p.m., motor
33 ¼ hp., 1,750 r.p.m., motor
34 ¼ hp., 1,750 r.p.m., motor
35 ¼ hp., 1,750 r.p.m., motor
36 5 hp., 1,200 r.p.m., motor
37 3 hp., 1,200 r.p.m., motor
38 3 hp., 1,200 r.p.m., motor
39 7½ hp., 450-900 r.p.m., motor
40 10 hp., 1,200 r.p.m., motor
41 3 hp., 1,200 r.p.m., motor
42 5 hp., 1,200 r.p.m., motor
43 1 hp., 1,809 r.p.m., motor
44 2 hp., 1,200 r.p.m., motor
Bins
Switch panel
Switchboard
Anchor
Shop
Store
Compressor underneath
C.L. stack
C.L. kiln, slope ¾ in 1 ft.
C.L. cooler
C.L. dust chamber
Calcine bins and No. 4 elevator
6 bins
Waste bin

General layout of Bald Eagle plant

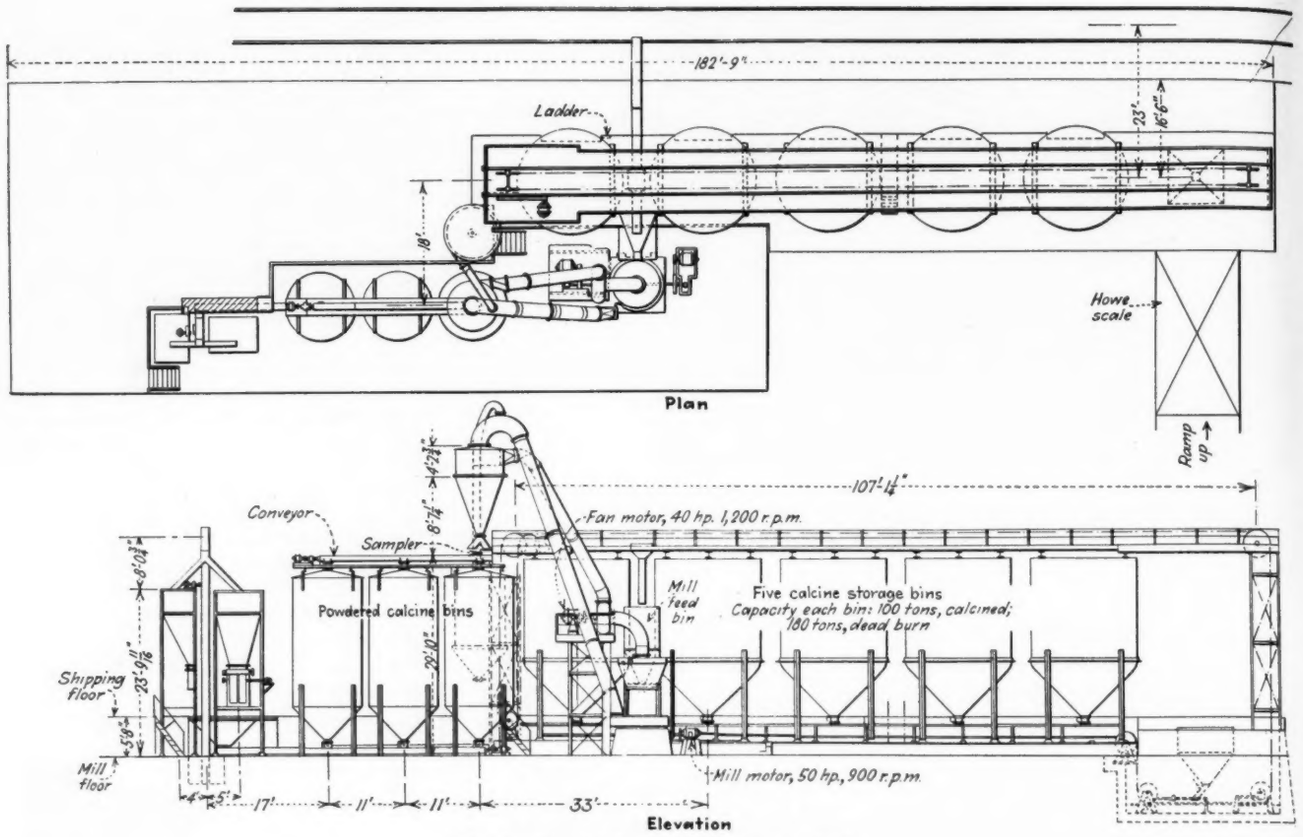


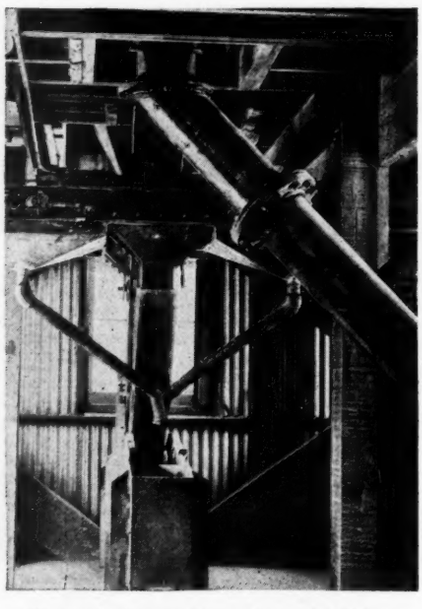
Fig. 2—General layout of Ingomar plant

tents of bin No. 1, containing 10 per cent silica, are sent to waste dumps. At present this material is being used for road repairs.

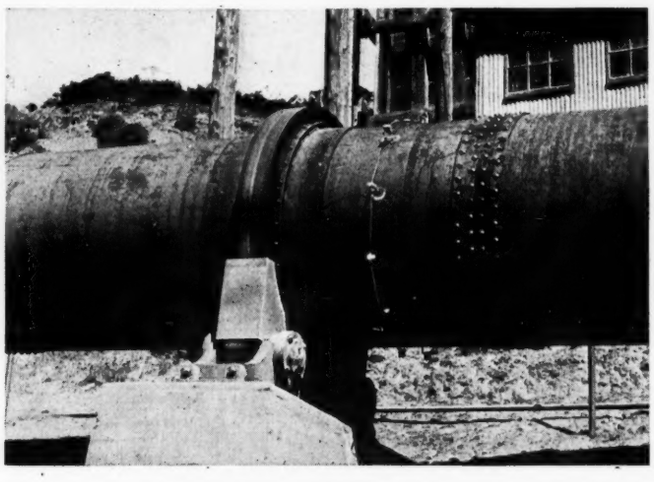
Grade of the contents of each storage bin is known and drawn off in measured proportions so as to give a blend of the desired silica limit. Each compartment of the crushed-mineral bin is provided with a gate and steel spout that discharges into the hopper of one of three Hardinge constant-weight feeders, which are carried on tracks in front of the bin spouts. From feeders the crushed magnesite falls onto an 18-in. conveyor belt that extends the length of the bins and discharges onto a cross conveyor, which, in turn, delivers the material to a 60-ton calciner bin. An automatic sampler removes a sample as the stream of material falls into the calciner bin. The desired blend to be sent to the calciner is obtained by drawing at suitable feed rates from one or more of the compartments of the crushed-mineral bin. Each of the three feeders delivers a maximum of 8 tons per hour. Maximum kiln tonnage is 4½ tons per hour. Normally, the feeders deliver sufficient product in 5 hr. to operate one rotary kiln 24 hr. The feeders are electrically interlocked, so that, in the event of a single bin being emptied, the feeders at the other bins cease operating.

The Bald Eagle plant contains one rotary calciner. Provision, however, has been made for the installation of two more when the demand for magnesite products justifies their installation. The shell dimensions of the kiln in operation are 6x100 ft.; inside diameter is 4½ ft.; the high-temperature zone is 40 ft. in length and lined with 9-in. periclase bricks; oil fuel is preheated by means of a coil of pipe under the kiln and is atomized by compressed air. The oil burner is of the Ray type, equipped with an air atomizing device of the company's own design.

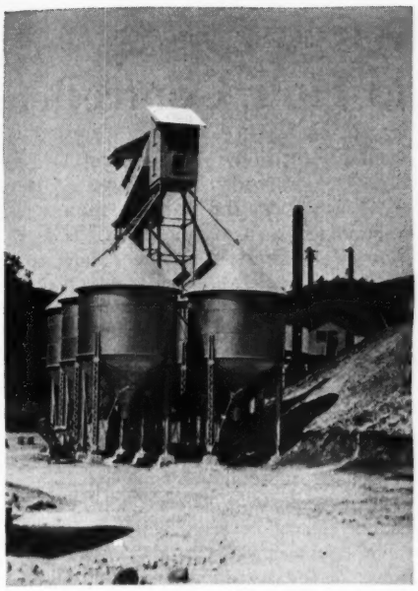
Heat control is effected by a ring of pyrometer leads at the high-temperature



Mechanical sampler and spouts below screen floor



At right—Pyrometer loads on calciner shell



Steel silos for calcined product

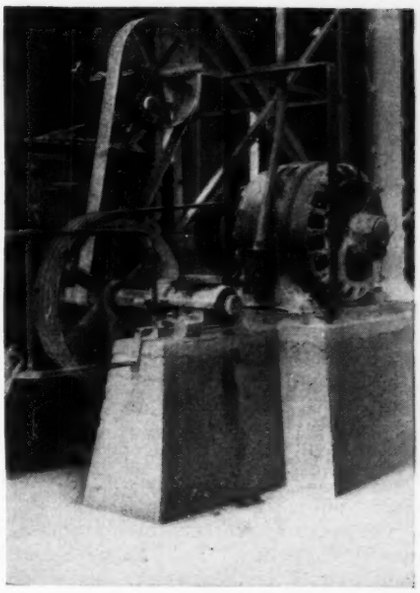
zone and another ring at the stack. A Hoskins pyrometer records the temperature. Maximum temperature employed, 1,760 deg. C., is used for the production of periclase. Normal temperature, 1,200 deg. C., is required for the calcining of the plastic magnesite.

The calcined product drops into a 4x40-ft. rotary cooler, the upper end of which is lined for a distance of 15 ft. The cooler discharges into an inclosed worm conveyor, and this, in turn, into the boot of a chain-type bucket elevator that delivers the material to a pent house above a nest of steel silos. A sample of the stream is cut by an automatic sampler before the material is conveyed and spouted into the silos. The six steel silos provide a finished storage capacity of 1,500 to 2,000 tons of finished products. Tops of the silos are conical, and the bottoms, also conical, are provided with gates and spouts. They are arranged in two rows, with a roadway under each row. Each bin weighs 39,000 lb.; has a volume of 6,750 cu.ft.; and holds 425 tons of periclase. Thus each bin has a capacity of 1.09 tons per 100 lb. of bin weight. Finished calcine is transported to Ingomar, about 16 miles distant. Trucking is contracted, and about 35 per cent return freight is provided. Truckloads average about 11 tons. The road grade is in favor of the load. Fuel oil is trucked from Ingomar, where a storage tank is available. The crushing and calcining plant requires four men on the day shift, one man on the evening shift, and one on the night shift.

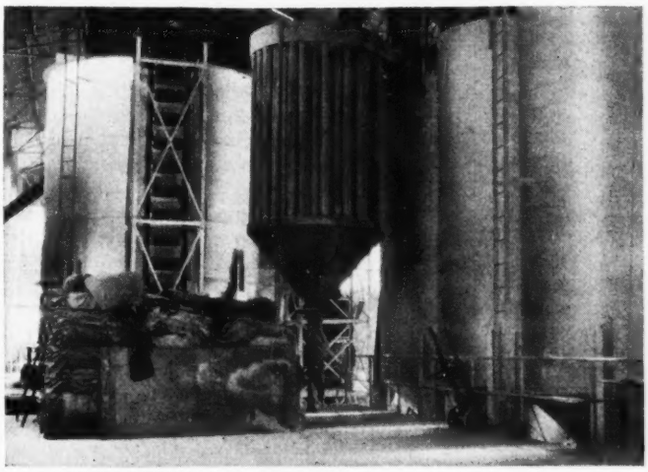
Two laboratories are maintained at the mine: one for physical tests and the other for chemical analyses. Systematic sampling provides close control on the chemical status of the finished products. Physical tests are made to determine setting time, expansion, and strength of plastic magnesite.

A constant-temperature room is maintained for the preparation of the test pieces. Buildings on the property, all of wooden construction, include a dormitory, mess hall, and office buildings, as well as cottages for men with families. A water system and fire protection are also maintained. A ½-ton York ice machine provides refrigeration and ice.

Connected power totals 197 hp., and power consumption about 135 hp. Electric current, supplied at 11,000 volts, is stepped down to 440 volts. Conveying machinery was supplied by the Link-Belt Company. United States motors are used in the plant, and the accessory electrical equipment is of General Electric manufacture. Timkin bearings are liberally used throughout the plant. The general layout is shown in Fig. 1.



V-belt drive of Raymond mill



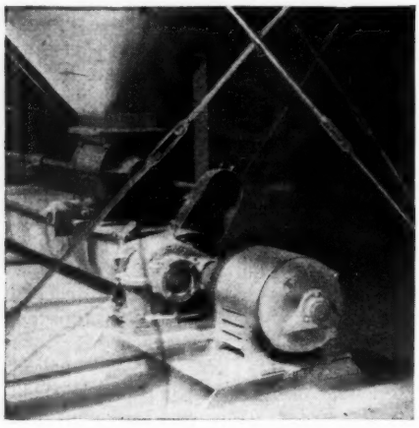
Dust filter; receiving bins and carrier system on left and finish bins on right

The plant at Ingomar, the railroad loading point, is in a single, steel-frame, corrugated-iron building, close to the railroad. Trucks dump into a 10-ton, steel-lined receiving hopper, which supplies a cross-over Link-Belt carrier system having a capacity of 30 tons per hour and serving five steel storage bins. Each bin holds 150 tons of plastic magnesite or 250 tons of periclase. The carrier system delivers to a spout that discharges into railroad cars. Contents of any one of the primary storage bins can be loaded into cars. In addition, each bin is provided with a side spout for manual loading. The carrier system will also discharge into the 10-ton feed hopper of a five-roll, high-side Raymond mill, driven by a 50-hp. motor through a V-belt, and equipped with cyclones, air sorting, and a dust filter.

Steel receiving bins served by Peck carrier system

Air-sorted, fine-ground, calcined magnesite is spouted to three 60-ton, closed-top, steel silos, from which it is retrieved by a worm-conveyor system that also includes an auxiliary automatic sampler. The conveyor, operated by an individual motor through a Link-Belt speed reducer, discharges into the boot of a bucket elevator that serves the hopper of a Bates sacking machine and also the hopper of another machine which is used for filling burlap bags. Paper bags and sacks are loaded manually into railroad cars. Ample storage space is available. The Raymond mill has a grinding capacity of 1½ to 2 tons per hour and delivers a product, after air sorting, that is 95 per cent minus 200 mesh. Total bin storage capacity at Ingomar is about 1,000 tons. The general layout is shown in Fig. 2.

The company markets three grades of plastic magnesite: Bald Eagle Select, containing 97 per cent magnesium oxide and quite free from bases; Bald Eagle Standard, containing 95 per cent magnesium oxide; and No. 20, a lower-grade plastic that contains 87 per cent magnesium oxide. In addition, two grades of artificial periclase, 100 per cent crystalline, are produced. These are: No. 93, containing 95 per cent magnesium oxide and not more than one-half of 1 per cent iron; No. 90, containing 92 per cent magnesium oxide and not more than 1 per cent iron, and having a specific gravity of 3.55. The periclase products are used for electric-furnace linings and in the manufacture of high-grade refractories.

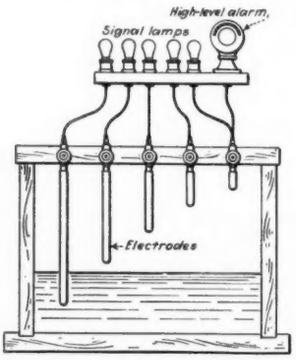


Screw conveyor system and sampler for delivering fine product from storage silos to elevator serving sacking machines

Both plants are splendidly designed and constructed. The operating personnel includes J. B. Perry, mining superintendent; Oscar Larson, plant superintendent; Carl Martin, accountant and office manager; Hugh Hartzel, chemist; and G. Silveria, mine foreman. Max Y. Seaton, vice-president and general manager of the company, with R. M. Catlin, Jr., chief engineer of several affiliated companies, is jointly responsible for the design of the plants.

Electrical Acidity Detector and Flow Controller

DEVELOPMENT of two automatic signals by the electrical department of Inspiration Consolidated Copper Company, at Inspiration, Ariz., has been of great value in the operation and maintenance of equipment at the leaching plant, according to Walter G. Scott, superintendent. The first innovation is a signal to show the presence of acid in the return condensate from the heat-transfer division. The solution, after precipitation, is heated for leaching purposes. This is accomplished by passing steam through lead coils, from which the condensate returns to the boilers. Two tanks are used for the return condensate, one of which is used for boiler operation while the other tank is being filled.



Tests for acidity are made once an hour by an operator, but acid might find its way into the condensate thus. This hazard was overcome by placing a small electrolytic cell, operating on alternating current, in the flow of the condensate from the vacuum pumps to the condensate storage tanks. The lead electrodes immersed in the condensate are spaced with 4½-in. centers. A 1,000-ohm Benjamin Telecode relay is connected in series to these electrodes. This relay can be depended upon to indicate the presence of one part of acid in 1,000. The source of electrical supply is the ordinary 110-volt lighting circuit. Presence of acid in the condensate is indicated by signal lights. A horn warns the operator of exceptionally strong acid.

The second electrical installation, shown in the accompanying sketch, determines the rate of solution flow through a launder. Five electrodes, of varying lengths, are suspended from a wooden holder bolted to the top of the launder; and, as they become immersed in the solution, circuits are established that light signal lamps at the main pump station, indicating the various solution levels. In addition, an alarm circuit operates on the high solution level, which is important, as the launders are so rated that the height of solution is indicative of the amount of flow. Consequently, the operator can detect any change by watching his signal lights, and the alarm on the highest solution level prevents overflows and splashing. Both devices were made under the direction of A. N. Voss, chief electrician, from reconditioned material in stock.

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Testing Non-metallic Mineral Properties

MEANS used for testing ground in limestone, feldspar, and other non-metallic mineral pits and quarries in advance of mining work are varied, just as in mining metallic ores. Diamond drills, churn drills, and test pits are most commonly employed. At Millville, N. J., the Menantico Sand & Gravel Company digs test holes with the aid of a 100-cu.in. Hayward orange-peel bucket suspended from a tripod and pulley and working inside a 12-in. pipe, which is sunk with, or a little in advance of, the bucket. About 40 ft. is done per day on the average. Two men can handle the task, but with three men additional footage is obtained, the three usually putting down two 20-25-ft. holes per day. The length of the first section of pipe depends on the ground. Subsequent sections are 4 or 5 ft. long.

Churn drills and a 6-in. hole are used by the North American Cement Corporation, of Albany, N. Y. The fines are baled out and emptied into a box, the cuttings for every five feet being kept separate and cut down later. Diamond-core drilling has been found most satisfactory by the Glens Falls Portland Cement Company, Glens Falls, N. Y. This company also uses churn drills and test pits as occasion warrants. The Pennsylvania-Dixie Cement Corporation, Nazareth, Pa., takes cutting samples while drilling blast holes with Sanderson Cyclone drills. The company favors core drills where a complete study of a quarry is to be made. At Hanover, Mont., the Three Forks Portland Cement Company uses a ¾-in. core drill on 100-ft. intersections. In putting down churn-drill holes, moreover, it samples every 4 ft. The holes are spaced on 20-ft. intersections. Test pits are used by United Feldspar Corporation, the lot being crushed and milled in usual fashion. A sample is obtained from the *finished* lot by mechanical samplers.

Trapeze Support for Stope-Back Trimmers

Roy H. Poston

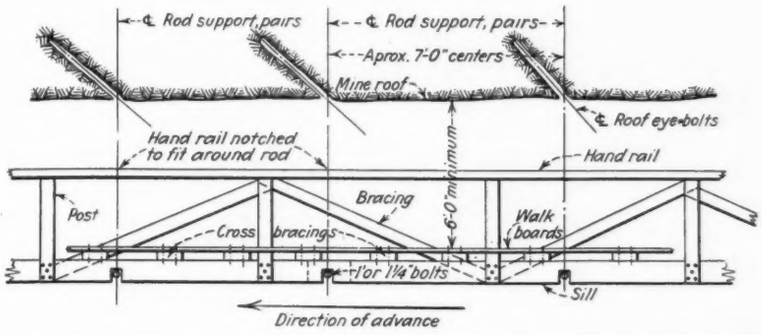

Fig. 1—Details of trapeze support

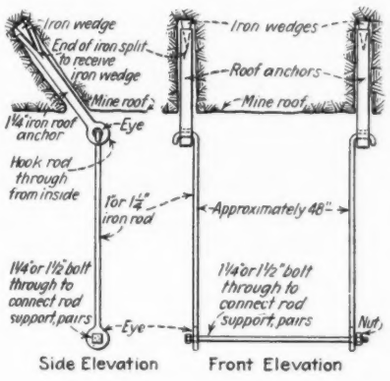

Fig. 2—Details of rod support

DATE of origin and name of the originator of the trapeze system of support used extensively by the roof men in high stopes at the mines of St. Francois are unknown to me, but it furnishes a safe, efficient, and relatively low-cost method for inspection and working of mine roofs in stopes considered too high for ladder or scaffold work. Almost all the material used in the construction of one of these units may be salvaged and re-used elsewhere when its purpose has been served in the first location.

A unit or section consists essentially of a pair of iron eyebolts, or roof anchors, suspended from the mine roof, from which are hung iron rods, connected by an iron cross member, upon which is placed the wooden structure required to support safely the roof men necessary for the work in hand. Approach to a unit is usually from a ladder, or from an adjacent bluff in the mine stope, the latter being a better place from which the first pair of holes may be drilled to receive the eyebolts. A pair of eyebolts (roof anchors) are set in the mine ahead of the bluff or ladder approach, and the hanging eyebolts, with the connecting rod in place, are suspended therefrom. Notched wooden sills, with cross bracing in place, are then placed across to the connecting rod, and the walkboards put in position.

Braces and hand rails follow in the order named. The driller then advances to the end of the unit and makes holes for the next two roof eyebolts, starting ordinarily with a 9-ft. drill steel, to gain distance ahead. Eyebolts (roof anchors) ahead of the last unit may be placed from a false platform resting on the previously completed section—a type of cantilever effect. The wedge in the end of the eyebolt (roof anchor) in the mine roof will hold it firmly in place, this eyebolt being the only part of the unit that cannot be removed for use elsewhere.

One trapeze over the center of a stope 30 ft. wide is usually sufficient. A roof man equipped with a 15-ft. mining bar can reach roof or pillar on either side of the trapeze. One drill operator and one carpenter usually comprise the construction gang, but the addition of a second carpenter will speed up the work considerably. New material is not always used for construction. The mine scrap pile often furnishes considerable material for this purpose.

A marked advantage of this system lies in the fact that it is above and out of the way of mining operations in the stope below. Periodically to call together men to move long ladders or scaffolds is unnecessary. Under favorable conditions, two experienced men will complete about 20 ft. of this type of construction in an 8-hr. shift.

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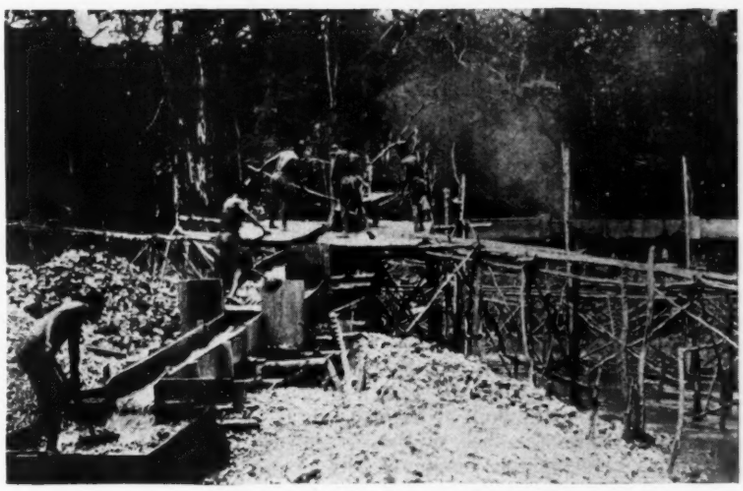
Belgian Congo Gold Developments

Raymond Anthoine



Alluvial gold plant on the River Mongbwalu, Belgian Congo

THE Kilo-Moto gold mines, in the northeast corner of the Belgian Congo, were discovered in 1904 under the colonization impetus of King Leopold. Operations began in 1905 at Kilo and in 1911 at Moto. Production reached 5,303.7 kg. of gold in 1931. Of this, 3,612.6 kg. was derived from the exploitation of alluvial and eluvial deposits. Kilo produced 2,426.8 kg. from 2,583,000 cubic meters of gravel and ground, of an average gold content of 0.94 gram per cubic meter.

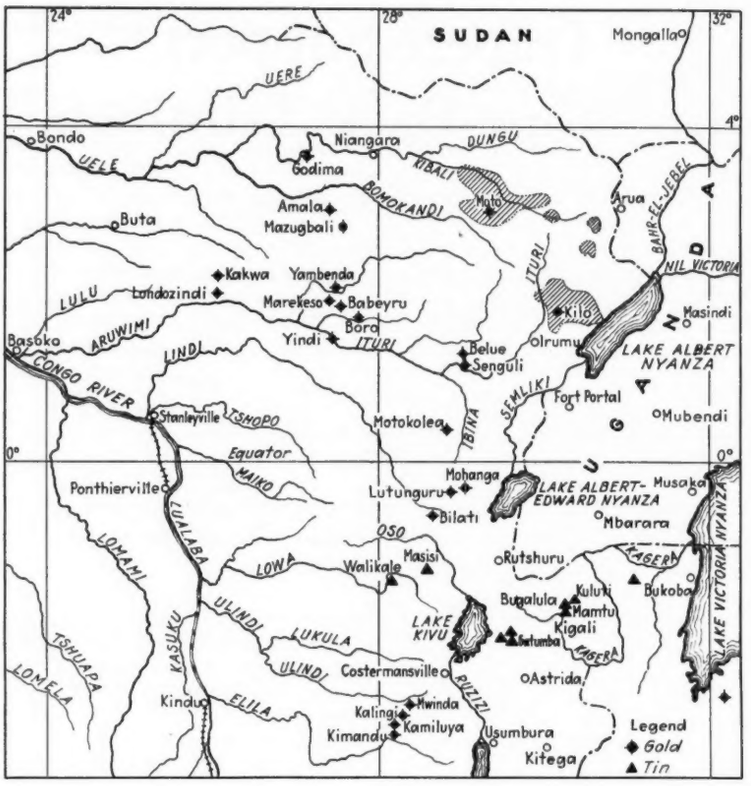
The Moto mines produced 1,185.8 kg. gold from 3,224,000 cubic meters of mineral. The grade of the deposit is the lowest treated in the world, managed by Europeans. It has not reached ½ gram per cubic meter. Technical improvements have permitted a gradual decrease in the grade of payable ore. Material is being successfully mined that carries no more than 0.18 gram per cubic meter.

Methods of operation vary with the nature of the deposit. They include hydraulic mining and excavation by dragline and by large dredge. The latest methods adopted, after many experiments, are well suited to the torrential currents of large tropical rivers.

The Kilo mines produced 1,434.9 kg. gold in 1931 from the treatment of 397,000 tons of ore. Practice involves use of Chilean mills, Huntington mills, Nissen stamp mills, tube mills. Flotation and roasting are applied according to the nature of the ore.

A program of modernization is proceeding concurrently with development of a central hydro-electric power plant, which will furnish about 10 million kilowatt-hours per year, at a price of six Belgian centimes (0.22 penny) the unit, an extremely low cost in a region far from the sea and without railways. Electricity is thus aiding the colonial engineer.

The alluvial camps are entirely managed and conducted satisfactorily by black labor. Kilo-Moto company employs more than 30,000 laborers in its mines and plants, supplying the needs of a village population of 100,000 persons.



Map of Gold-Tin Region, Belgian Congo

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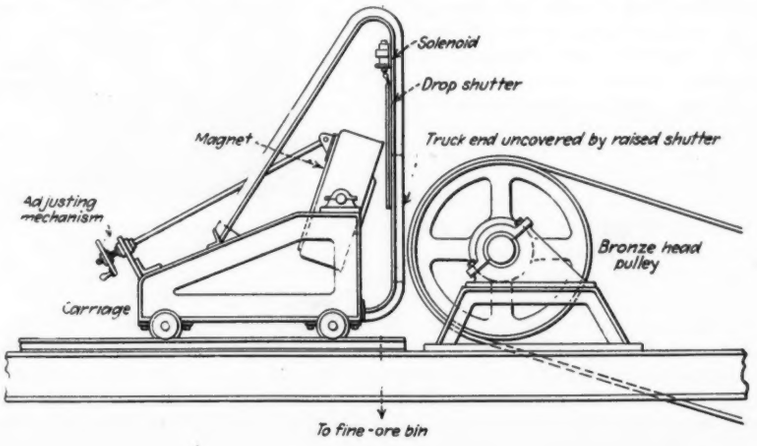
Magnet Deflects Fifty Tons Scrap Annually

BY employing an electromagnet to remove tramp iron and steel from ore before milling, a company in South Africa has effected economies and increased metallurgical efficiency. Previously, the pieces of metal associated with the ore were pounded by the stamps, causing damage and unnecessary wear. Moreover, the resultant contamination of the pulp lowered the value of the amalgam and increased the consumption of cyanide.

The magnet used is mounted on a movable truck, as shown in the accompanying sketch, and placed at the discharge end of the belt conveyor that delivers ore to the battery bin. Design of the device permits the face of the magnet and the end of the truck uncovered by a drop shutter to be adjusted to the stream of ore. The shutter falls when the current passing through the coils of the magnet solenoid is interrupted, thus preventing metal scrap from falling into the ore bin. Residual magnetism in the magnet is sufficient to hold the scrap for about ten seconds, whereas the shutter acts instantaneously. At intervals of 24 hours the truck and magnet are backed away from the conveyor, the current is interrupted, and the load of metal, weighing about 300 lb., is released, to be sent to the foundry for use as casting metal.

The magnet has an over-all diameter of 36 in., and a center pole of 12 in. Lifting capacity is 3 tons or more of solid iron and steel on contact with the pole piece, and about 1,000 lb. of tramp iron. Total weight of the device is 2,100 lb. Cooling water for the magnet is furnished by a small motor-driven pump, and direct current at 90 volts for excitation is generated by a motor-generator set, equipped with a drum-type controller, switch gears, and control meters. About 4,000 lb. of scrap metal is removed each month from the 70,000 tons of ore milled in that period. Economies effected by the device repaid its initial cost in a few months.



Flotation of Apatite in Russia

N. K. Karchmer

IN AN ARTICLE entitled "The Phosphate Deposits of the Kola Peninsula," by Dr. L. G. Khvostovsky, *E.&M.J.*, May 11, 1931, the mining operations of the Apatite Trust, with headquarters in Leningrad, were briefly described. In view of the increasing activity and interest in the flotation of non-metallic ores, an account of a highly successful undertaking in this field should be of value to readers of this publication. I will therefore describe the operations of the flotation plant constructed by the Trust for beneficiating apatite ore. The plant, consisting of two sections, each capable of treating 650 metric tons daily, was placed in operation in the summer of 1931. Five additional sections are now under construction. The initial plant was largely experimental, and many changes in construction and flowsheet were made in the early stages of operation. This article will be confined largely to the flowsheet finally adopted and now in use.

Khibinogorsk, the site of operations, is 19 km., by a branch line, from Apatite, a railroad station on the Leningrad-Murmansk railroad, 1,200 km. north of Leningrad. The mill is 6 km. from the mine, a lake lying between the two. The ore is delivered to the crushing plant in trains of 15-ton, standard (Russian) gage, inverted-V bottom, self-dumping cars, and is dumped into a 160-ton, reinforced-concrete, hopper-bottomed bin, with two discharge openings, only one of which is now in service.

The principal crushing equipment consists of two No. 20-A Telsmith gyratory crushers and two 5½-ft. Symons cone crushers. The ore bin discharges through a hand-operated finger-gate on to a 42-in. steel-pan conveyor of German manufacture. This slopes 25 deg. and can feed either crusher. The gyratories take a minus 14-in. feed and deliver a 3-in. product, which goes to the cone crushers on 24-in. belt conveyors, inclined 17 deg. The cone crushers, adjusted to give a minus 1-in. product, discharge on to 24-in. belt conveyors, inclined 20 deg. These conveyors in turn feed a 36-in. belt conveyor which delivers the crushed ore to the fine-ore bin. The latter conveyor is made in three sections: a short inclined section fronting the cone crushers, a long section sloping 17 deg. to the fine-ore bin, and a horizontal section equipped with an automatic distributor over the bin. Each has an individual drive.

At present, one gyratory and one cone crusher, running approximately eight hours daily, are sufficient, the other crushers serving as spares. The crusher building was so built as to leave room for installing another primary and another secondary crusher. These will be provided before all seven sections of the plant are completed.

Gyratories and cone crushers are belt-driven, the former by 150-hp., slip-ring, International General Electric motors and the latter by 200-hp. motors of similar type and make. The 24-in. conveyors, of Russian manufacture, are belt-driven by motors of Russian make. Rollers and steel substructure of the 36-in. conveyors are of German manufacture. The latter conveyors and the pan conveyor are driven by reduction gears direct-connected to motors of Russian manufacture. All conveyor belting was supplied by the Soviet rubber factories.

The crushing problem is simple. Approximately, 65 to 70 per cent of the ore is apatite, the rest being chiefly nepheline, with a small quantity of ilmenite. As the apatite is granular and friable, it breaks readily into fines. The nepheline is tough, with no cleavage, and is harder to crush or grind.

The fine-ore bin is of 2,200 tons' capacity and is similar in construction to the coarse-ore bin. It is divided into two sections, each equipped with nine Southwestern Engineering Company ore feeders. On each section, the feeders discharge on to two 14-in. horizontal belt conveyors, which in turn deliver on to a 14-in., inclined belt conveyor, the discharge of which is distributed to two rod mills. The conveyor belts in the grinding sections are all of Russian manufacture, and are belt-driven by motors of similar make.

Both of the grinding sections are identical. Each consists of two 5x10-ft. Tompkins rod mills operating in partial open-circuit with 6x25-ft. Dorr classifiers, and two 5x10-ft. Tompkins ball mills operating in closed circuit with 6x25-ft. Dorr classifiers. The degree of fineness sought is minus 80 mesh, Tyler-screen scale.

Two-stage grinding is employed, the primary classifier overflow being a final product. The sand from these classifiers is divided, part returning to the rod mills and part feeding the ball mills. The latter, operating in closed circuit, deliver a final product. Classifier overflow is approximately 33 per cent solids, by weight.

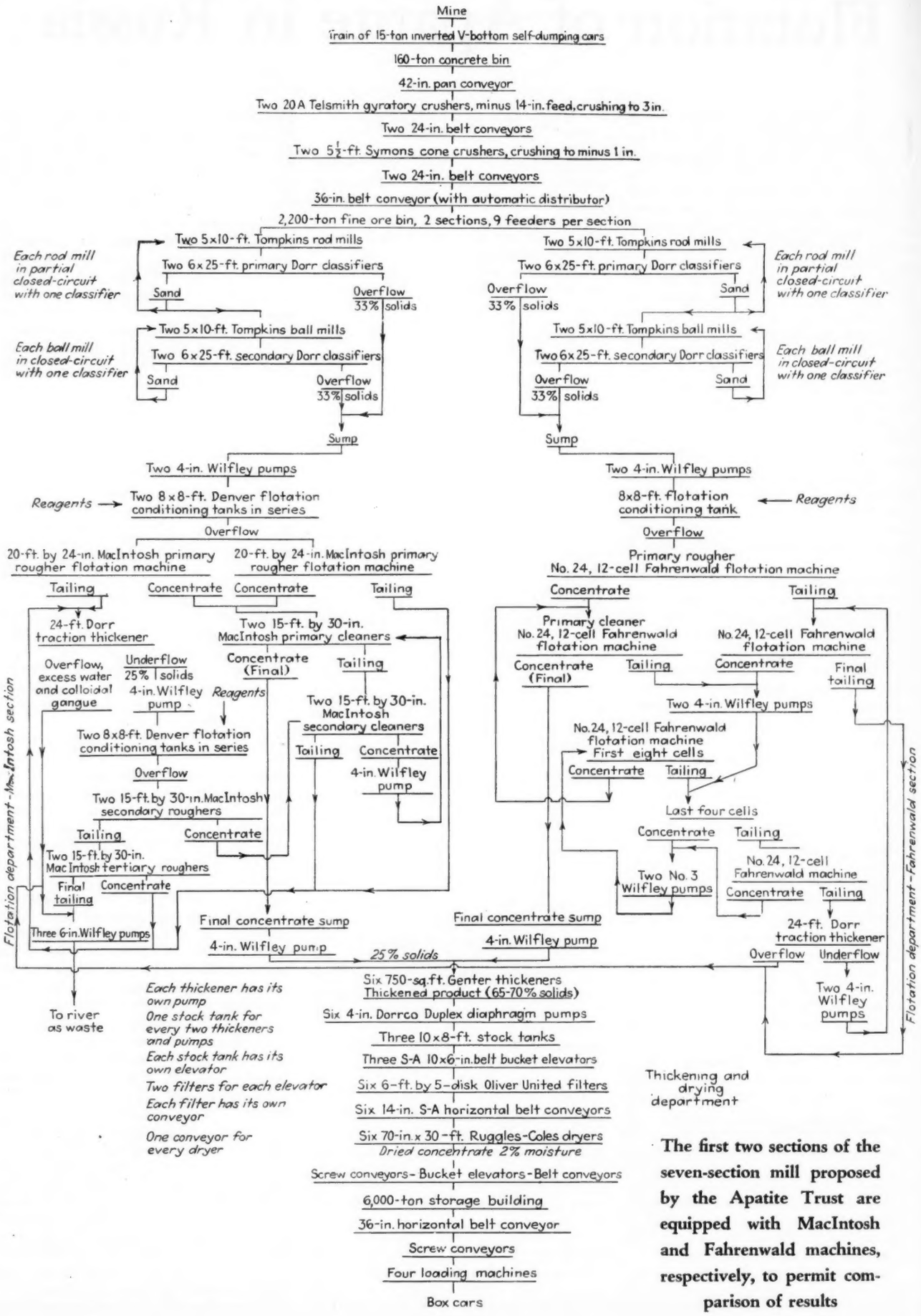
The evolution of the grinding flowsheet was an interesting problem. As originally designed and installed it included rod mills grinding in closed circuit to produce a 20-mesh product. This material was to be classified in an intermediate classifier to remove the minus-80-mesh material; and the plus-80-mesh material was to be ground in ball mills operating in closed circuit. The initial test revealed that under the then existing conditions the rod mills could not make a product as coarse as 20 mesh. Attempts to make a 48-mesh product in the rod mills were also unsuccessful. Consequently, the intermediate classifiers were abandoned, with the view of operating the rod mills in open circuit, removing the minus-80-mesh material and regrinding the sands in the ball mills.

Evidence quickly accumulated showed that under such conditions the capacity of the ball mills was very low. Owing to a selective action in the primary grinding, the deslimed sand returning from the primary classifiers consisted mostly of nepheline. With this sand as feed, the capacity of one ball mill varied between 50 and 75 tons per day. The flowsheet, as now working, was finally selected as the best solution for this problem, for the time being. Subsequent tests revealed that either one rod mill or one ball mill could readily grind 250 tons daily of this ore to minus 80 mesh. Each of the five additional sections now under construction will be equipped with three ball mills, in single-stage grinding.

All the grinding mills have combination drum-scoop feeders, herringbone gears, and anti-friction bearings on the pinion shaft. The rod mills are direct-connected to 100-hp., slip-ring, International General Electric motors, and the ball mills are direct-connected to similar motors of 125 hp. The speed of the rod mills is 21 r.p.m. and that of the ball mills 29 r.p.m. To convert the rod mills into ball mills or vice versa, only the pinion gear and the discharge trunnion liner need be changed. The rod mills have a low discharge and the ball mills a center discharge. The Dorr classifiers were made in Russia and are belt-driven by motors of Russian make.

Combined overflow from the primary and secondary classifiers forms the flotation feed and is pumped to the conditioning tanks by means of a 4-in. Wilfley pump on each section. In the flotation department, one section is equipped with MacIntosh flotation machines, furnished by the General Engineering Company, of Salt Lake City, Utah, and the other section is equipped with Fahrenwald machines, furnished by the Denver Equipment Company, of Denver, Colo. The two sections are referred to as the "MacIntosh" and "Fahrenwald" sections respectively.

The major flotation equipment in the


Mine
Train of 15-ton inverted V-bottom self-dumping cars
160-ton concrete bin
42-in. pan conveyor
Two 20A Telsmith gyratory crushers, minus 14-in. feed, crushing to 3 in.
Two 24-in. belt conveyors
Two 5½-ft. Symons cone crushers, crushing to minus 1 in.
Two 24-in. belt conveyors
36-in. belt conveyor (with automatic distributor)
2,200-ton fine ore bin, 2 sections, 9 feeders per section
Two 5x10-ft. Tompkins rod mills
Two 6x25-ft. primary Dorr classifiers
Sand
Overflow 33% solids
Each rod mill in partial closed-circuit with one classifier
Two 5x10-ft. Tompkins ball mills
Two 6x25-ft. secondary Dorr classifiers
Each ball mill in closed-circuit with one classifier
Sump
Two 4-in. Wilfley pumps
Reagents
Two 8x8-ft. Denver flotation conditioning tanks in series
8x8-ft. flotation conditioning tank
Overflow
20-ft. by 24-in. MacIntosh primary rougher flotation machine
Primary rougher No. 24, 12-cell Fahrenwald flotation machine
Tailing
Concentrate
24-ft. Dorr traction thickener
Two 15-ft. by 30-in. MacIntosh primary cleaners
Concentrate (Final)
Overflow, excess water and colloidal gangue
Underflow 25% solids
4-in. Wilfley pump
Two 15-ft. by 30-in. MacIntosh secondary cleaners
Two 8x8-ft. Denver flotation conditioning tanks in series
Two 15-ft. by 30-in. MacIntosh secondary roughers
Two 15-ft. by 30-in. MacIntosh tertiary roughers
Final tailing
Three 6-in. Wilfley pumps
Flotation department - MacIntosh section
Primary cleaner No. 24, 12-cell Fahrenwald flotation machine
No. 24, 12-cell Fahrenwald flotation machine
Concentrate (Final)
Final tailing
No. 24, 12-cell Fahrenwald flotation machine First eight cells
Last four cells
Two No. 3 Wilfley pumps
No. 24, 12-cell Fahrenwald machine
24-ft. Dorr traction thickener
Overflow
Underflow
Two 4-in. Wilfley pumps
Flotation department - Fahrenwald section
Final concentrate sump
4-in. Wilfley pump
25% solids
Six 750-sq.ft. Genter thickeners
Thickened product (65-70% solids)
Six 4-in. Dorrco Duplex diaphragm pumps
Three 10x8-ft. stock tanks
Three S-A 10x6-in. belt bucket elevators
Six 6-ft. by 5-disk Oliver United filters
Six 14-in. S-A horizontal belt conveyors
Six 70-in. x 30-ft. Ruggles-Coles dryers
Dried concentrate 2% moisture
Screw conveyors - Bucket elevators - Belt conveyors
6,000-ton storage building
36-in. horizontal belt conveyor
Screw conveyors
Four loading machines
Box cars
To river as waste
Each thickener has its own pump
One stock tank for every two thickeners and pumps
Each stock tank has its own elevator
Two filters for each elevator
Each filter has its own conveyor
One conveyor for every dryer
Thickening and drying department

The first two sections of the seven-section mill proposed by the Apatite Trust are equipped with MacIntosh and Fahrenwald machines, respectively, to permit comparison of results

MacIntosh section consists of four 8x8-ft. Denver conditioners, two 20x24-in. MacIntosh cells, eight 15x30-ft. MacIntosh cells, and one 8x24-ft. Dorr traction thickener, supplied by The Dorr Company, New York. Reagents used are sodium silicate and a collecting and frothing reagent locally prepared. The latter is made by dissolving in a solution of caustic soda a crude product locally known as "peat tar," which is produced from the peat deposits so abundant in various districts of Russia. Denver reagent feeders are used on both sections.

After addition of reagents, the pulp is conditioned in two of the conditioners. The overflow from the latter receives a preliminary treatment in the 20-ft. machines functioning as primary roughers. Tailing from these is thickened in the traction thickener, which unit serves a double purpose in removing excess water after primary roughing and removing a large quantity of colloidal gangue with the overflow. The thickener underflow, containing about 25 per cent solids, is pumped through a 4-in. Wilfley pump to the two remaining conditioners, with further addition of reagents.

The primary rougher concentrate is cleaned in two primary cleaners, the concentrate from the latter being final and the tailing flowing to two secondary cleaners. Overflow from the secondary conditioners is treated in two secondary and two tertiary roughers. Concentrate from the former flows to the secondary cleaners, and that from the latter joins the tailing of the primary roughers. The tertiary roughers produce the final tailing. Concentrate from the secondary cleaners is pumped through a 4-in. Wilfley pump to the primary cleaners, and the tailing joins that of the primary roughers.

The MacIntosh machines are equipped with individual motor and reduction-gear drive, side air inlet, gland eliminators, and perforated rubber rotor covers. Air at 2-lb. pressure is provided by two No. 4 Roots blowers, one of which is in service and the other held as a spare. Blowers and conditioners have Tex-rope drives.

All Wilfley pumps in the plant are direct-connected to motors and are placed in pairs, one pump being in operation and the other a spare.

In the Fahrenwald section, the principal equipment consists of one 8x8-ft. Denver conditioner, five No. 24 Denver Sub-A (Fahrenwald) machines, each having twelve cells and a V-rope dual drive, and one 8x24-ft. Dorr traction thickener. Reagents used are sodium silicate and oleic acid. No compressed air is required by the Fahrenwald machines in treating this ore.

Overflow from the conditioner is treated in the first Fahrenwald, which serves as a primary rougher. Concentrate from this machine flows to the fifth machine, a primary cleaner, and the tailing to the second machine, which produces the final tailing. Concentrate from the latter joins the tailing of the primary cleaner and is pumped by a 4-in. Wilfley pump to the ninth cell of the third machine, the tailing from the latter flowing to the fourth machine. The concentrate from the last four cells of the third machine joins the concentrate of the fourth machine and is pumped by a 3-in. Wilfley pump to the first cell of the third machine. The tailing of the fourth machine flows to the thickener, the discharge of which is pumped by means of a 4-in. Wilfley pump to the second machine. Concentrate from the first eight cells of the third machine flows to the primary cleaner, and the tailing flows into the ninth cell of the third machine. The primary cleaner produces the final concentrate.

Overflow of both thickeners and the final flotation tailing from both sections flow to the head boxes of three 6-in. Wilfley pumps. One of these pumps is a spare. The other two, in service, discharge through a 10-in. pipe line, approximately 1 km. long, into the river which forms the outlet of the lake previously mentioned.

The difference between the reagents used in the two sections probably requires explanation. Oleic acid gives satisfactory results on either type of machine. However, owing to the abundance and cheapness of peat tar, experiments were made with a view of substituting it for oleic acid. On the MacIntosh machines these experiments were successful, the peat tar giving practically the same results as oleic acid; but on the Fahrenwald machines, it was found unadaptable, owing principally to its intense frothing action. From the viewpoint of metallurgical results the two types of machines offered little to choose from, when oleic acid was used on both.

Water for the plant is derived partly from the condensers in the power plant and partly by pumping directly from the lake. In winter, it must be pumped from beneath the frozen surface of the lake, and consequently its temperature then is very low. An increase in the temperature was found to be accompanied by improved metallurgical results. Using steam to heat the water, and balancing the cost of heating against metallurgical results, the economical point was established as 6 deg. C., and an effort is made to keep this as the minimum temperature throughout the flotation circuit.

The ore produced proved readily amenable to flotation. In mining it, the grade sought is 28 per cent P_2O_5. The grade frequently falls below this figure, however, although seldom exceeding it. Recovery is consistently maintained at approximately 95 per cent, in a concentrate averaging 39.5 per cent P_2O_5. The floatability of the apatite is high, and little difficulty is experienced in maintaining the high recovery; but the grade of concentrate is maintained by liberal circulation of middling products, as the flowsheet indicates. In working out the flowsheet, the principle followed was to combine for re-treatment the various middling products of similar chemical analysis. The flotation froth is white, but the presence of considerable ilmenite gives it a dark color. As the floatability of ilmenite was found to be higher than that of nepheline, with the reagents used, the flotation operators can estimate fairly closely the grade of concentrate by its color. The reagents are introduced directly into the conditioning tanks. When an attempt was made to add the reagents in the grinding mills, the classification was seriously affected.

Approximately 75 per cent of the ore is recovered as concentrate. Such a low ratio of concentration is unusual in flotation work. The plant itself, however, is unusual in having a thickening and filtering section much larger than is customary in a flotation plant of this size.

Concentrate from each flotation section is pumped by a 4-in. Wilfley pump to the thickening section, where it is combined and thickened in six 750-sq.ft. Genter thickeners, employing wet vacuum. Each of these is provided with a vacuum pump—a Connersville Type B, three-lobe, 6x9-in., cycloidal rotary unit, equipped with a Tex-rope drive.

The concentrate settles readily and is free-filtering. The feed supplied to the Genter thickeners is 25 per cent solids, and the thickened product averages 65-70 per cent solids. Each thickener is discharged by means of a 4-in. duplex Dorrco diaphragm pump, equipped with a motor and a chain drive mounted on the pump frame. The thickeners and the filters that follow later are arranged in pairs, so that one stock tank serves two of each. Dorrco pumps discharge into three Geco, 10x8-ft. Goldfield-type agitators, serving as stock tanks. The stock tanks discharge through Genter mud valves into the boots of three Stephens-Adamson 10x6-in., belt bucket elevators. Each elevator feeds two 6-ft. x 5-disk Oliver-United filters, driven through reduction gears direct-connected to motors and equipped with a variable-speed mechanism. Each filter has a five-compartment filtering tank. Automatic vacuum-regulating valves are supplied, by means of which a low and high vacuum can be maintained on the upper and lower portions, respectively, of the filter disks. Vacuum is supplied by three Ingersoll-Rand, XRB-1, Tex-rope-driven vacuum pumps, of 2,215 cu.ft. per minute displacement, and the filtrate is removed by 1½-in. centrifugal pumps. Two vacuum pumps are required for six filters. One pump serves as a spare. The average percentage of moisture in the filter cake approximates 12.

The cake from each filter falls on to a 14-in. horizontal Stephens-Adamson belt conveyor, which discharges into a 70-in. x 30-ft. Ruggles-Coles dryer. The dryers are wood-fired and driven through reduction gears direct-connected to motors. Cyclone-type dust collectors are used, the dust trapped falling through a vertical pipe to join the dryer discharge.

Dried concentrate, averaging 2 per cent moisture, is stored in a building of 6,000 tons' capacity. The dryer discharge is conveyed through a series of screw conveyors to the boots of two chain-bucket elevators, the discharge of which is distributed to two 18-in. horizontal belt conveyors, equipped with automatic distributors. These conveyors are over the concentrate storage building and discharge into it. The floor of the building is equipped with a series of discharge openings and gates, placed longitudinally in the center. After passing through the hand-operated gates, the concentrate falls on a 36-in. belt conveyor, running in a tunnel under the building. From this conveyor, the concentrate is distributed by means of a series of screw conveyors to four loading machines, which load it into standard box cars. Part of it is shipped for export and part for supplying the needs of the Soviet chemical factories, where most of it is consumed in the production of superphosphate.

The chain bucket elevators are of Russian make. All other equipment in the concentrate storage and loading section was manufactured in Germany.

Induction motors taking 380-volt current are used throughout the plant. Power for milling is temporarily generated locally. The completion of a hydro-electric project, "Nivastroy," will provide power for the entire plant after all seven sections are complete.

In conclusion, I might mention that this plant is but the beginning of an ambitious structural and industrial program. As previously stated, it is being enlarged. At present the mill tailing is discarded, but plans are being made for a plant to recover the nepheline in it. Nepheline has several industrial uses: for example, in the tanning of leather, in the glass industry, and more important, as a source of aluminum. Work on the construction of a plant to extract aluminum from it has already begun. In addition, chemical plants are to be erected in the vicinity. Completion of this program will convert what two years ago was a barren wilderness into the industrial and cultural center of the North in western Russia.

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Recovering Alluvial Gold

GOLD-SAVING APPLIANCES, including the cradle or rocker and the dry blower and dry shaker, are described, with the aid of simple, explanatory cuts (here reproduced), in Mining Review 54, of the South Australia Department of Mines, Adelaide.

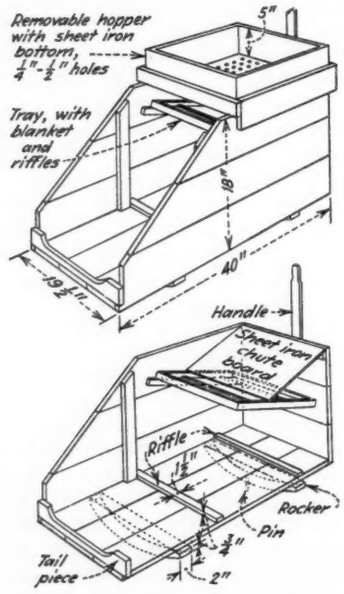


Fig. 1—Cradle or rocker for use where a water supply is available

Water is necessary for the operation of the cradle or rocker. Construction of the device is illustrated in Fig. 1, the lower view showing the cradle with hopper and side removed. Material to be treated, especially if clayey, must be thoroughly puddled or disintegrated in a tub or otherwise, before being fed. Feeding is done by shoveling the gravel on to the sheet-iron screen. At the same time, water is poured on the screen and the cradle rocked evenly and continuously. Oversize is removed by hand from the hopper. Screen undersize slides down the chute board and on to and over the riffled apron plate, which sometimes is covered with corduroy or canvas. Two such plates may be used. The apron discharges to the back end of the sloping and riffled cradle bottom, over which the gravel passes to discharge at the front end. Gold is caught principally on the apron plate, which can be removed for cleaning at intervals, the concentrate thus obtained being panned to recover the gold. The riffles in the rocker bottom serve to catch any gold that escapes over the apron. The tailings should be sampled and panned occasionally as a check. Cleanings from the bottom of the cradle may be re-run. The rocking motion, plus the slight slope of the rocker, concentrates the gold and keeps the material moving forward. Experience will serve to indicate the proper slope. If this is too great, the gold will not have time to settle behind the riffles. If too flat, the material will pack behind the riffles and the gold pass over the top. The cradle should not be too short nor should the apron plate.

Where water is scarce, the dry blower is used. One design is shown in Fig. 2. *A* is a shaking screen of punched sheet iron to which a shaking and rocking motion can be imparted by hand. Undersize passes through to metal chutes, *B*, and oversize is discharged over the edge. The chutes, *B*, deliver to a removable tray, *C*, provided with riffles and a bottom of hessian or toweling backed by metal gauze. This tray may be 10 or 12 in. long and 6 in. wide, or larger, and sits in the top of a wind box *D*, having clack valves in the bottom, through which air from the 18- or 20-in. bellows, *E*, enters. The wind box sits directly on the bellows. The latter is operated from the screen *A*, through gearing *F*. Screen *A* and bellows are set in a steel frame at suitable angles. In Fig. 2, the screen motion is longitudinal, but in other designs it may be sideways. Machines of this type, when properly designed, are capable of recovering fine gold.

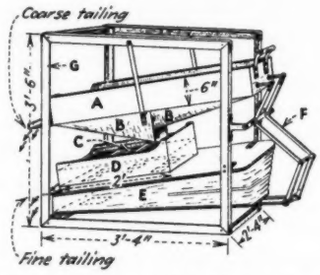


Fig. 2—Type of dry blower common in Australia

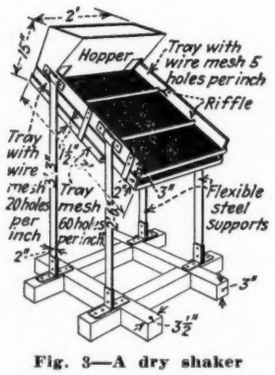


Fig. 3—A dry shaker

Another device for use where water is scarce is the dry shaker, Fig. 3. It consists simply of a frame supported either on a central axis, on which it can be rocked, or on four flexible uprights, as illustrated in the accompanying drawing, which permits a shaking motion to be imparted to the frame.

Simple Method Of Constructing Relief Models

Harold R. Brisley

THE method to be outlined for making a relief model map of a section of country is based on that described in the April 13, 1931, issue of *Engineering and Mining Journal*, the invention of B. B. Elderbeck, requiring a movable, perpendicular electric drill and considerable time in construction. It did not prove practicable for a large relief model. In endeavoring to save time and expense in making a 5x8-ft. model, I hit upon what I believe is a simple, convenient, and effective method for relief map construction, especially when a rugged country with great elevation differences must be molded.

The relief model was made on the same vertical as horizontal scale—of $\frac{1}{10}$ in. to 100 ft.—and has for its extremes in elevation 3,400 and 7,600 ft. The map, representing an area 15 miles long and 8 miles wide, was constructed on four equal sections, convenient for transportation, which can be assembled in five minutes. Each section weighs 80 to 120 lb. including the tray in which it is made—in three months, by one engineer and a part-time helper.

A relief model was needed that would show the ruggedness of parts of the terrain in contrast with rolling hills and valleys. Elevations had to be depicted accurately, as they occurred, and the country had to be represented as it would appear from the air at an altitude of about 14,000 ft. To accomplish this, a formula was developed for a non-shrinkable surface molding clay, that could be worked easily yet permit sufficient time for molding before setting. None of the available commercial preparations had these characteristics.

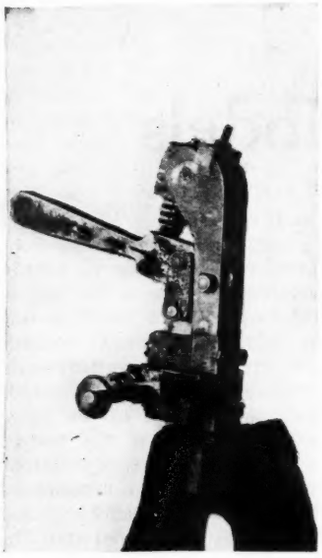
The only equipment necessary for map construction is a wire cutter (see the illustration), to make a $\frac{1}{16}$-in. rod with a straight-end cut. Such a cutter can be made in any machine shop, and has an accuracy of one 1/1000 of an inch. An electric beater, also shown in an illustration, is useful for making paper pulp, but the pulp may be made by hand if a beater is not available.

A contour map of the proposed country was enlarged to the desired size by photographic projection. As the completed map was a large one, enlargements had to be made in several sections, later carefully glued together to form the complete 8x5-ft. contour map. Extensive enlarging can be accomplished in this manner. The map in question was stepped up eleven diameters. Next, it was cut into four equal sections, and trays were made of $\frac{3}{4}$-in. lumber so that the bottoms would be the exact size of each map section, and the sides high enough to clear the highest elevation. The sides of the trays, which match the other sections, are held in place by screws, permitting ready removal when the map is assembled. Each section was then made separately.

A good grade of molding clay, as used in schools, was spread in the bottom of the tray to an even depth of $\frac{3}{4}$ in. On top of this was spread the contour map enlargement. The $\frac{1}{16}$-in. welding rod wire was then cut into pieces each $1\frac{1}{2}$ in. long, for use along the lowest elevation contour of the map. With a piece of the same wire, sharpened on the end, holes were punched through the map on the contour line, about $\frac{1}{4}$ in. apart. The $1\frac{1}{2}$-in. wires were then placed perpendicularly in these holes, and pushed down through the molding clay until they reached the bottom of the tray. The next higher contour line was then selected, punched in the same manner, and wires of a length corresponding to the elevation of that contour line were inserted along its length. If the lowest contour line of the map is 3,400 ft., the wires placed on this line are 1.5 in. long. If the next contour line is 3,500 ft., and the vertical scale is 0.1 in. equals 100 ft., the wires for this contour line are cut 1.6 in. long; and so on until wires of the proper length are placed through every contour line of the map. A thin mixture of plaster of paris was then made up, and as rapidly as possible poured into the tray and between the wires to a depth of $\frac{3}{4}$ in., or just to the level of the top of the 1.5 in. or lowest contour wires. The plaster of paris must be mixed with enough water so that it is thin enough readily to spread between the wires. When it has set, the wires are held rigid and the map is ready to mold. The surfacing material is then forced down between the wires and smoothed off to the level of their tops, the surface roughened up to appear natural and small drainage ways pressed in before

Section of relief model with elevation wires in place, but before plaster of paris has been poured

Completed section of relief model



Left: Welding-rod cutter. Right: Mixer for making paper pulp.

the surface hardens. To finish, the surface is sprayed with a thin glue, and dusted with fine soil put through a 100-mesh sieve. Only a small area can be treated thus at one time, because the fine soil must be sprayed on the surface before the glue dries. Excess dust can be blown off. If the surface is waterproof, shellac may be used instead of glue, but glue is easier to work with.

For making the molding clay, first make a paper pulp by agitating a cheap grade of paper in water until it thoroughly disintegrates. Squeeze out the water and add to the pulp an equal weight of flour, at the same time adding enough water to make a thin paste. To this paste add sufficient plaster of paris so that it can be rolled between the hands without being sticky. Only small quantities of the finished product should be made up at one time, as it will become too hard to work in about an hour. When set, it is free from shrinkage and is just as hard as plaster.

To relieve the weight of the map after it is finished, it may be lifted out of the tray and the molding clay removed. This clay can then be worked up and used over again in another section.

■ ■ ■

Jigging and Flotation of Lead-Zinc Ore

THE principal economic mineral in the ore treated by Hecla Mining, at Gem, Idaho, is fine-grained galena, associated with small amounts of marmatite. Jigs have been retained because the ore is ideal for jigging operations, and the present smelter settlement schedule favors jig concentrate rather than flotation concentrate.

Mine ore is crushed to 5 in. and then passed over a grizzly having 3-in. spaces. Undersize is further sized by a vibrating screen having 1¼-in. holes. Grizzly and vibrating screen oversize products fall onto a conveyor belt from which smelting ore and waste are removed by hand sorting. The milling ore remaining is crushed to 1¼-in. and joins the vibrating screen undersize as feed to the concentrator.

The concentrator utilizes jigs as far as possible; middling and tailing are ground and further treated in separate flotation units. Ore from the sorting plant is crushed to minus 30-mm. by rolls, and then sized for jig feed by trommel screens. The sized products are treated in jigs, which produce concentrate, middling, and tailing. Tailing after grinding is treated in a machine that produces lead concentrate.

The zinc in the original ore concentrates sufficiently in the jig middling to warrant treating this product by selective flotation, in two machines operating in series. The first produces lead concentrate; the second, zinc concentrate. A third flotation unit is provided for the treatment of primary slime by flotation, resulting in the production of lead concentrate.

For 1930 the total recoveries of silver, lead, and zinc were 96.1, 97.4, and 65.0 per cent, respectively· jig concentrate accounted for 62.5, 65.8, and 40.1 per cent of the total silver, lead, and zinc, respectively, the remainder being obtained by flotation operations.

Milling cost for April, 1931, was 55c. per ton of ore treated. Further details are given in Information Circular 6600, by W. L. Zeigler, superintendent of the plant, and published by the U. S. Bureau of Mines, Washington, D. C.

Ventilation of Gaseous Drifts

PROSPECT DRIFTS that have been driven in the basal quartzite of the East Tintic district, Utah, have frequently broken into zones and open fissures containing carbon dioxide gas, writes J. S. Finlay, mine superintendent, North Lily Mining Company.

During periods of low barometric pressure, in one heading of the North Lily mine, the quartzite emits gas in such quantities that 10,000 to 15,000 cu.ft. of air per minute will not sufficiently dilute the gas to enable a carbide lamp to burn, an atmosphere decidedly dangerous for workers. Experiments, however, showed that an air pressure of about 3-in. water gage would keep the gas in the rock fissures, and, moreover, would force the gases caused by blasting to enter the fissures.

Equipment used at the North Lily to drive 10,000 cu.ft. of air through 4,000 ft. of 16-in. metal piping, at 3-in. water gage, consists of two 30-hp. fans, arranged in series. These fans were designed and built at the mine. Air is piped to the working face through a door, 1,000 ft. back. An adjustable slide above the door is used to control and maintain the air pressure between the door and the face and to provide circulation of the air. This method of ventilating a gaseous drift has been in use several months, during two weeks of which period the barometer registered particularly low. Atmospheric conditions in the drift between the door and the face have been satisfactory for workers throughout the period.

Another device used at the property to protect the health of workers and to promote efficiency in mining operations is an atomizer, which is connected to the compressed-air and water lines. Just before a round is fired in a drift, the spray is turned on and directed toward the face. When the blast occurs, the drift is full of water vapor, which collects and settles the gases quickly, avoiding powder headaches on the part of the workers. This device uses only a fraction of the compressed air usually consumed in blowing blasting gases out of a drift in which a round has been fired.

Caging and Skip-Loading Devices

Lucien Eaton

IN CONSIDERING the hoisting capacity of a shaft, too much importance is usually assigned to rope speed and too little to the time required for loading and unloading the skip or cage. The arrangements made for loading and unloading, which might be called the "terminal facilities," are equally as important as the "long haul."

As the depth at which ore is mined increases, the problem of efficient hoisting assumes more and more importance, and the choice of the system best suited to conditions at the mine deserves careful consideration. When increase of hoisting capacity is desirable, the first thought that suggests itself is likely to be to increase the hoisting speed or the size of the skips. Sometimes, however, a change in the facilities for filling the skip will shorten the loading time to such an extent that the requisite increase in capacity may be obtained without changing either skip or hoist.

In earlier plants, high hoisting speed was considered the first essential for obtaining large capacity, and large investments were made in powerful, speedy hoists; and the question of skip-loading was almost overlooked. I recall a mine where an expensive hoist was hoisting a 7½-ton skip to surface in one minute, and the time required to fill the skip was three minutes, but this is an unusual condition. When cages are used, the loss of time at both ends of the trip is commonly greater than when skips are used.

Caging Devices—In coal mines, all hoisting is likely to be done from one level, and a large plant and intricate layout are justified. Effective automatic caging devices have been developed, by means of which the empty car is pushed off the cage as the loaded car enters it. Such devices are seldom used or warranted in metal mines.

At shafts in which small cages are used, caging is done by hand. The empty car is pulled off the cage and pushed out of the way, and the loaded car then pushed on, the process being reversed at the unloading point. Time lost at each point varies from 30 sec. to 2 min. Only when all hoisting is done from one level can the two operations be carried on simultaneously. In addition to loss of time, the question of labor is involved—an important consideration.

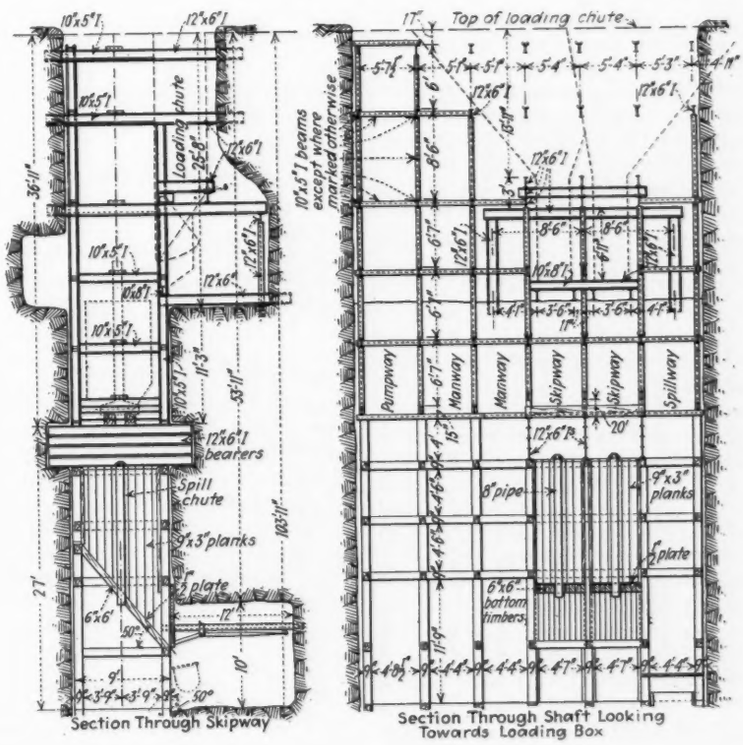
Notable among the few metal-mine installations in which mechanical caging devices have been provided are those at some of the large shafts on the Rand. Here the cager consists of a long-stroke compressed-air cylinder, mounted between the rails. This operates a plunger, which pushes the loaded 6- or 8-ton car upon the cage, the loaded car in turn pushing the empty off on the other side and the car-stops in the track operating automatically. The loading time has been reduced to 10 sec., and the number of men required is small.

Skip-Loading Devices—The various methods of transferring ore from cars to skips and the devices used may be classified as follows: (1) Direct from car to skip; (2) pocket holding one skip load; (3) storage pocket discharging directly into skip; (4) storage pocket for one grade of ore discharging into measuring pockets, each of which holds one skip load; (5) storage pockets for more than one grade of ore, discharging into measuring pockets; (6) storage pockets for more than one grade of ore, discharging into an intermediate pocket, from which either measuring pocket may be filled; (7) storage pockets for more than one grade of ore, discharging into a measuring pocket which will fill either skip. These methods will be discussed in turn.

1. *Direct From Car to Skip*—This method of loading entails the least capital outlay, and has great flexibility in handling different grades of ore and waste. It is suitable for mines where the amount of ore on a level is insufficient to warrant construction of pockets, or where the mine output is much less than the hoist capacity. To prevent spill in loading, a short slide is often used, through which the ore is dumped, or, in inclined shafts, baffle plates may be hung over the sides of the skip. Occasionally large skips, which hold more than two or three carloads, are filled in this way, and cars are dumped from both sides at the same time, or are dumped in rotation from one side only. In the latter instance, loading is slow. In most installations considerable delay is experienced, either because of the skip waiting for cars or because of cars waiting for the skip.

If ore is hoisted from several levels and is coarse and likely to block the pockets, delays may be lessened by dumping the cars directly into the skip through a chute. I have in mind a mine where the skip held 5 tons, and where 2½-ton cars were used on most levels. Although pockets were provided, they were customarily used only

Fig. 36—Loading pocket and shaft at a diamond mine, Kimberley, South Africa



This is one of a series of articles on mine equipment.

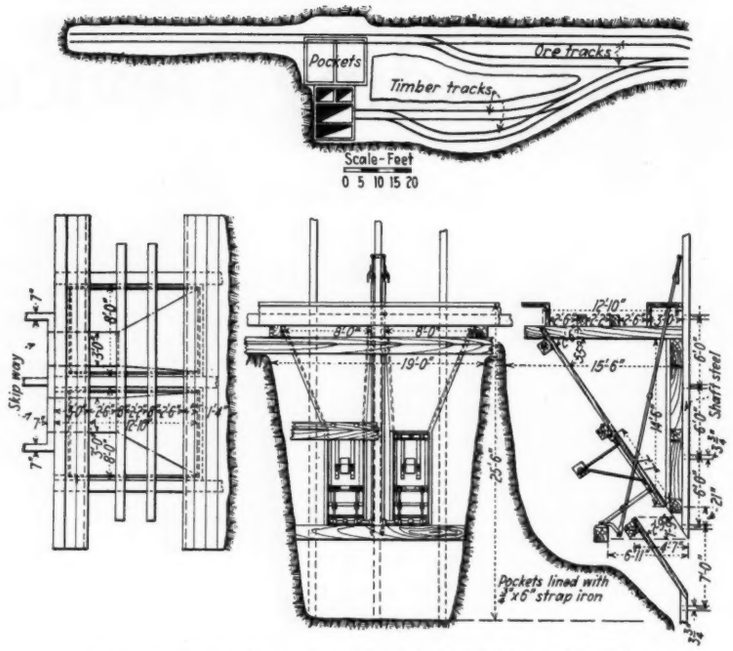


Fig. 37—Shaft plat and pocket details, Holmes mine, Ishpeming, Mich.

as chutes, and two cars were dumped in succession, unless the first car contained fine ore. In that circumstance this was dumped into the pocket, but the second car was not dumped until the pocket had discharged its contents into the skip, and could be used as a chute. By dumping the cars one after the other, 40 sec. to 1 min. was required to fill the skip, but this delay was less than that caused by occasional blocked pockets. When 5-ton cars were introduced, loading time was reduced to 10 sec.

2. *Pocket Holding One Skip Load.*—This system has many advantages, especially for mines that produce several different kinds or grades of ore, as well as waste, which must be kept separate. Capital expenditure is not large, speed of loading is as great as if a storage pocket were used, and delays are not serious if a good supply of ore is kept on hand in cars. Extra cars for ore storage, if the amount of ore on each level is not large, are less expensive than storage pockets, and the flexibility obtainable in keeping grades separate is almost perfect. Capacity of the skip must be the same as that of the car or a multiple of it.

Two examples of this arrangement of loading pockets may be cited. The first is at the diamond mines at Kimberley, in Cape Province, South Africa. Here the ore, "blue ground," is hauled to the shaft in 16-cu.ft. cars by endless rope. The rate of delivery of cars is very uniform. Ten carloads, the capacity of the skip, are dumped into the pocket one after the other, and the skip is loaded from the pocket in less than 5 sec. At these shafts 5,000 tons is hoisted daily in nine hours with two skips from a depth of 1,650 ft. General arrangement of pocket and shaft are shown in Fig. 36. At this mine only one grade of ore is handled, and a continuous supply is provided by the large ore-passes serving the orebody and by the endless-rope haulage system.

The second example is that of the Holmes mine of the Cleveland-Cliffs Iron Company, Ishpeming, Mich. This was a comparatively small mine with only half a million tons of ore on a level. Four grades of ore besides waste, making five grades in all, had to be kept separate. In this mine the ore was hoisted from a depth of 1,450 ft. in two 4-ton skips in balance. The cars held 4 tons each, and one pocket was provided for each skip. The plan of the level and layout of the pockets are shown in Fig. 37. In practice the ore was hauled to the shaft in trains of six to eight cars, which were pushed past the shaft, until the last car was spotted over one of the pockets. The locomotive then left the cars, picked up a train of empties on the siding by the shaft, and returned to the orebody. Loaded cars were spotted over the pockets by a small air-hoist, and were dumped into the pockets during the time when the skip was in motion. The time taken by the skip in going to surface and back was ample for dumping and the time actually consumed in loading the skip was only 4 sec. Only one skip tender was required.

The drawings show that the doors of the pockets are essentially the same, each being a door hinged at the top and operated by a toggle. In the mine at Kimberley, the door opens into the shaft, and has wings on the sides, so that, when open, it forms a chute to prevent spill. At the Holmes mine the door drops downward, and discharges the contents of the pocket into a chute leading to the skip. In both cases the door is locked open and locked shut by a toggle.

3. *Storage Pocket Loading Directly Into Skip.*—At some mines, where only one grade of ore is to be handled, and where a measuring pocket is unnecessary, the skip is filled directly from the storage pocket. This takes longer than filling from a measuring pocket, and the variation in loading and the spill are greater. The most essential feature is the means provided for stopping the flow of ore quickly and positively. Overcutting doors or arc gates, closing from above downward, are not usually successful in coarse ore, and fingers or undercutting gates are used. An example is shown in Fig. 38. In this instance the fingers are of an unusual type. The points that come in contact with the ore are renewable, and the

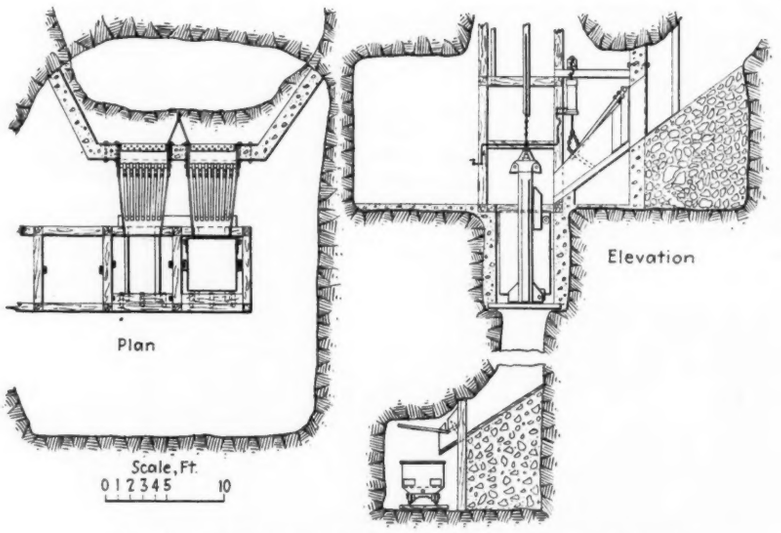


Fig. 38—Skip-loading arrangement employing undercutting gate with fingers of unusual type. United States Bureau of Mines Circular No. 6326.

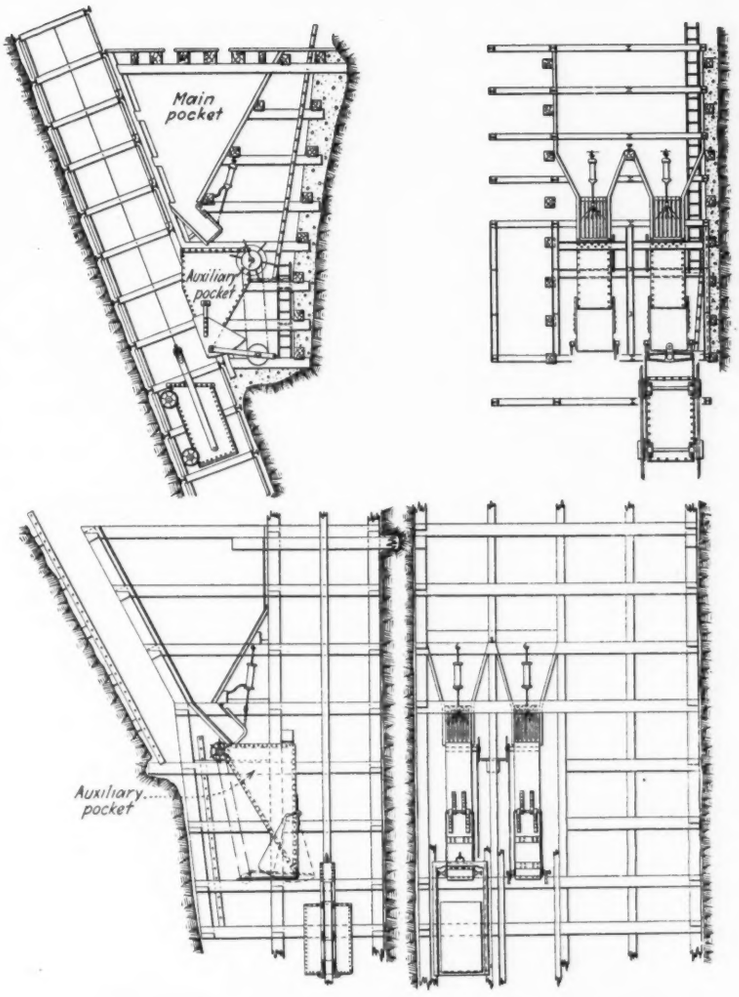


Fig. 39—Two examples of measuring pockets used for loading skips. Pioneer mine, Minnesota. Each pocket holds a skip load. See also Fig. 40.

fingers are heavy enough to stop the flow of ore effectively and quickly. Other types of finger chutes are shown in the illustrations of storage pockets in connection with which measuring pockets are used.

4. *Storage Pocket for One Grade of Ore, Discharging Into Measuring-Pockets, Each of Which Holds One Skip Load.*—Some mines, especially those producing low-grade ore which requires concentration, have only one grade of material to hoist. The quantity of waste produced is small, and as it sometimes contains a small amount of metal, although too little for it to be classed as ore, hoisting it with the ore and putting it through the mill has been found less expensive than keeping the two grades separate. At these mines one large storage pocket into which the ore is dumped either directly from the cars or through chutes from higher levels is customarily located at the shaft. The ore from the storage pocket is drawn off into measuring pockets, sometimes called "flasks," each of which holds exactly one skip load and from which the skips are filled alternately. The measuring pockets themselves are filled while the skips are in motion. When a skip comes to rest under its pocket, all that is necessary is to open the gate and discharge the contents into it. This takes only two to five seconds, so that the time lost in loading is very slight. Furthermore, as haulage and hoisting are independent, a minor delay in one department does not affect the other. Examples of this kind of storage pocket are shown in Figs. 39 and 40.

Construction of the storage pocket itself varies with local conditions. In hard, strong ground no lining or support may be necessary, but in other formations concrete and steel, or timber, protected by steel plates or rails, may be necessary. The storage pocket usually has a grizzly at the top to keep out pieces of ore or rock large enough to block the chutes below, but this is not always necessary or advisable. Examples may be seen in Figs. 39, 41, 42, and 44. Although the design varies, such variations are not important and are fewer in number than the differences in design of measuring pockets.

Measuring pockets may be divided into two general classes. In the first, the amount of ore put into the pocket is regulated by the attendant, as his judgment and skill may permit. Such a pocket is illustrated in Figs. 39, 41, and 44. In the second class, the stream of ore from the storage pocket is allowed to flow until it stops of its own accord because the measuring pocket is full, and it is then cut off by the gate, or chute-closer, of the storage pocket. This gate is usually an undercutting door operated by a compressed-air cylinder. A pocket of this class is shown in Fig. 40.

An undercutting gate always leaks somewhat, the spillage accumulating on the floor below; but this difficulty may be overcome, in those operations where the air cylinder is not below the chute, by a lip and slot so placed in the back of the measuring pocket that the spill will fall into it and the ore in the pocket will not fall out. Such an arrangement is shown in Fig. 40. In a few instances, the charge of ore going into the measuring pocket is weighed, but this is a refinement not usually attempted.

In mines which produce ore on more than one level, if the level interval is not too great, a storage pocket is not needed for every level. Instead, one may be built on every other level, and the ore that is hauled to the shaft on the upper of every two levels, where no pocket has been built, is dumped down ore passes, which discharge directly into the storage pocket on the lower level. These ore passes are usually equipped with chutes and gates, to permit control of the delivery of ore to the pocket.

5. *Storage Pockets for More Than One Grade of Ore, Discharging Into Measuring Pockets.*—An arrangement of this kind is shown in Fig. 41, a drawing of the storage and measuring pockets at the Athens mine, Negaunee, Mich. (a description of which was published in the *Proceedings* of the Lake Superior Mining Institute). The storage pocket is divided into three compartments and has four chutes. The largest compartment is in the middle and has two chutes, and in it is dumped the grade of ore which constitutes the bulk of the mine production. From this compartment either measuring pocket can be filled, and the ore hoisted with either skip; but the end compartments, one of which is used for waste and one for another grade of ore, each discharge into one measuring pocket only, and the contents of each can therefore be hoisted in only one skip. This arrangement makes it more difficult to keep the grades separate on surface, and consequently slows up hoisting to a certain extent, but at this mine the respective amounts of waste and the second class of ore are not large enough to give much trouble.

At this storage pocket the chutes are closed by vertical fingers, which are very effective for the ore handled. The measuring pockets are of the first class mentioned, the amount of ore placed in

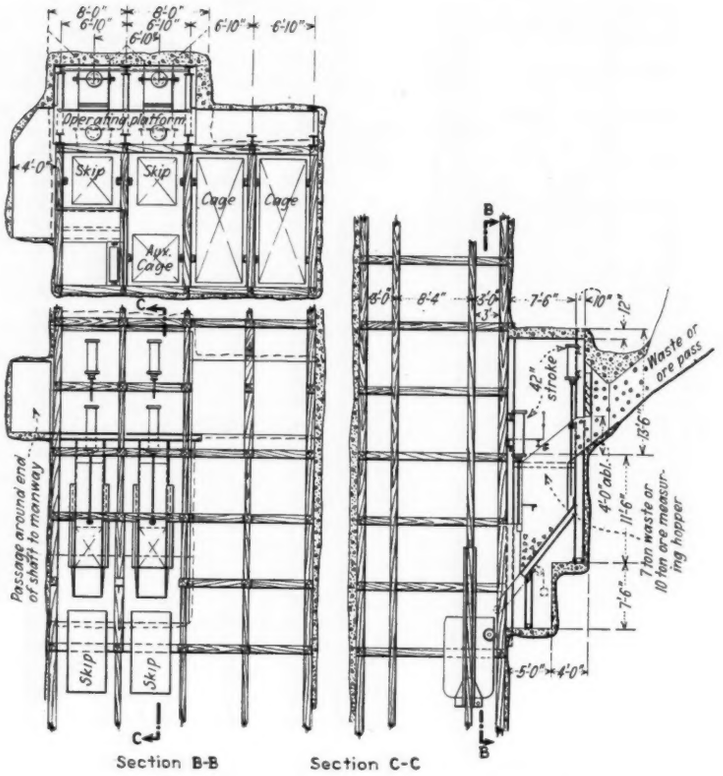


Fig. 40—Another example of measuring pocket holding one skip load. Frood mine, Ontario.

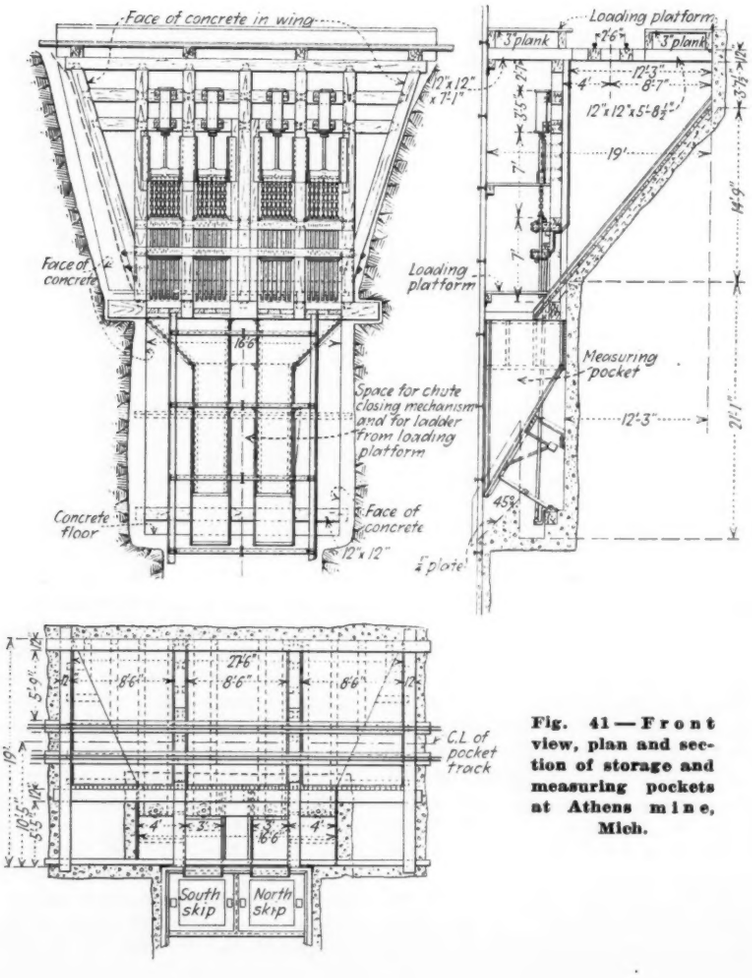


Fig. 41—Front view, plan and section of storage and measuring pockets at Athens mine, Mich.

them depending on the skill and judgment of the attendant. The discharge floor is of the drop-bottom type, as illustrated in Fig. 37. It is quick and positive, and discharges the entire contents of the pocket as soon as it is opened, the loading time being 2 to 4 sec.

6. *Storage Pockets for More Than One Grade of Ore, Discharging Into an Intermediate Pocket, From Which Either Measuring Pocket May Be Filled.*—The intermediate pocket is under the mouth of the storage pocket, and holds ten to twenty skip loads. It can be filled with waste or with different grades of ore, as desired, and hoisting of one grade can be maintained with both skips until the pocket is empty. This arrangement is used by the United Verde Extension Mining Company, and is illustrated in Fig. 43. This method works well, if the ore is not too coarse, coarse ore being likely to give trouble at the gates of the auxiliary pocket. More excavation and a greater depth of shaft are required, however, than with other arrangements.

7. *Storage Pockets for More Than One Grade of Ore, Discharging Into a Measuring Pocket Which Will Fill Either Skip.*—This arrangement calls for only one measuring pocket, which can be filled from any compartment of the storage pocket. It has two doors, so that the contents can be discharged into either skip. This makes a simple, flexible arrangement, requiring a minimum of excavation. The general scheme is illustrated in Fig. 42, and the details of the pocket are shown in Fig. 45. This measuring pocket is practically two pockets, placed face to face, with the front walls removed. The dividing wedge between the two doors is an easily replaceable manganese-steel casting, and the bottom edges of the doors are beveled, so that they have a substantial bearing at the point of contact. Shims can be introduced under the toggle bearings to take up wear and to reduce leakage.

A measuring pocket of this type makes it possible, with a minimum of shifting in the distributing apparatus on surface, for one man to load both skips with any one of the grades of ore or with waste. Its only disadvantage is that the attendant has only half as much time in which to fill the measuring pocket as he has if two pockets are used. If the gate of the storage pocket is of the proper size and type, however, no delay should be experienced on this score, unless the distance hoisted is short. The gates can be arranged for automatic cutoff, as shown in Fig. 40.

Devices for Changing Skips and Cages.—At many mines, the skips must be replaced with cages at the beginning and end, and even in the middle, of every shift, to get the men into and out of the mine quickly and safely. The devices used are of four classes: (1) overhead cranes; (2) transfer trucks; (3)

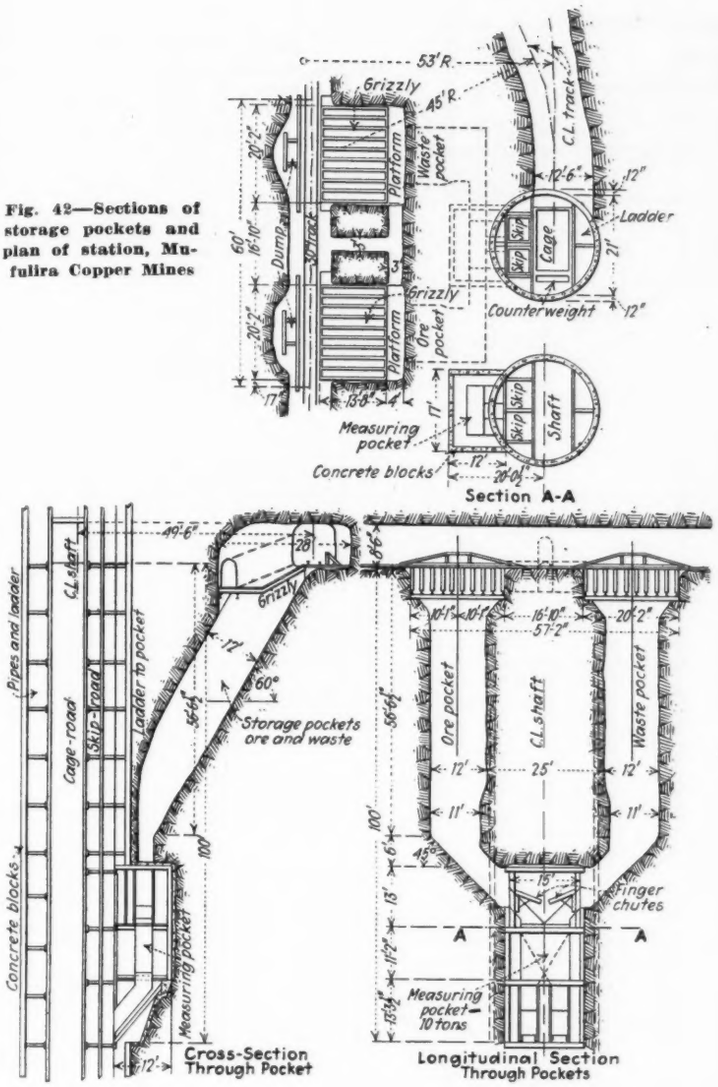


Fig. 42—Sections of storage pockets and plan of station, Mufulira Copper Mines

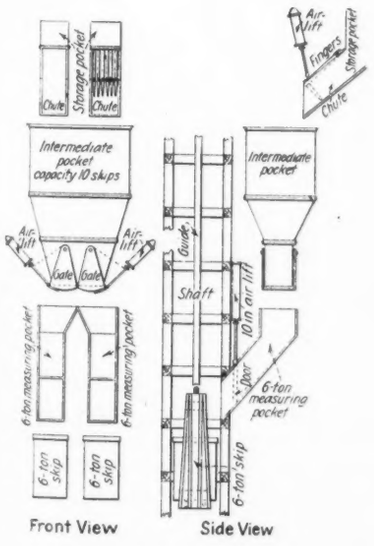


Fig. 43 — Arrangement of storage, intermediate and measuring pockets for loading skips, United Verde Extension shaft

removable bodies; and (4) switch tracks. The first class is the one most used.

At inclined shafts which have no back runners the method is simple. A jib crane, attached to the headframe, is swung over the track from one side. From it three chains of the proper length, equipped with hooks, are suspended. The hooks are then attached to the skip, which is lowered until its weight rests on the chains. Then the hoisting rope is disconnected, the crane swung back out of the way, taking the skip with it, and another crane, carrying the cage or man car, is swung into place over the track. The hoisting rope is connected to the cage, which is raised until the chains are slack, and these are then disconnected and swung back out of the way.

In a vertical shaft the same procedure may be followed if the arrangement of the hoisting compartments will allow it, but some quick method of throwing the guides out of line must be used.

An ingenious method of moving the guides, together with a good system of overhead cranes, is used at the United Verde Extension mine at Jerome, Ariz., and is shown in Fig. 46. An overhead track consisting of 12-in. I-beams is built under the headframe and extends across the hoisting compartments behind the guides. On this track on each side of the shaft runs a trolley that serves each compartment, one trolley carrying two trucks, B and B_1, runs in cage. The change is made in the manner described. The method of swinging the guides out of line is easily understood from the drawing, and involves the use of hinged arms in pairs, which can be locked together to hold the guide in place. Three to four minutes is required for the change.

An example of the second class of changing devices by means of transfer trucks is shown in Fig. 47. This method has given good service at the Cliffs Shaft mine at Ishpeming, Mich., for many years. A wide-gage track, A, carrying two trucks, B and B_1 runs in front of the shaft, as shown. Its elevation is such that the floors of the trucks are exactly level with the top of the collar set. At the back of the hoisting compartment is a drawbridge, C, which can be thrown down across the shaft and has rails on top, which meet rails on the trucks, B and B_1, when they are in position. Sliding fishplates keep these rails in line during the transfer. On the transfer trucks are other trucks, D for the skip and D_1 for the cage.

The guides are of $7\frac{3}{4}$x$7\frac{3}{4}$-in. Oregon fir in 22-ft. sections, hinged at the top and held in place at the bottom, at the collar, between two short pieces of heavy angle iron. They can be swung back 1 ft. at the bottom by a toggle lever, similar in construction to the ordinary mine switch stand. This amount of movement is sufficient to clear the guide shoes of either skip or cage.

In changing, the procedure is as follows: The skip is hoisted 6 ft. above the collar, the drawbridge is thrown down, transfer truck B is spotted immediately in front and its rails are connected with the rails of the drawbridge. Truck D is pushed out on the drawbridge under the skip, and the skip is lowered upon it. The rope is then disconnected, the guides are thrown back, and skip and truck are pushed off the drawbridge onto truck B, and are moved to one side. Truck B_1, with the cage upon it, is then brought into line, and the process is reversed. The whole procedure takes $2\frac{1}{2}$ min.

The third method of changing from skip to cage is used in vertical shafts, and entails removing the box of the skip from the bail and substituting the body of a cage. A good example is found at State Mines, on the East Rand. Here the bail of the skip is made unusually long, to make room for a double-deck cage. The skip box is detached by removing the dump axle from the bear-

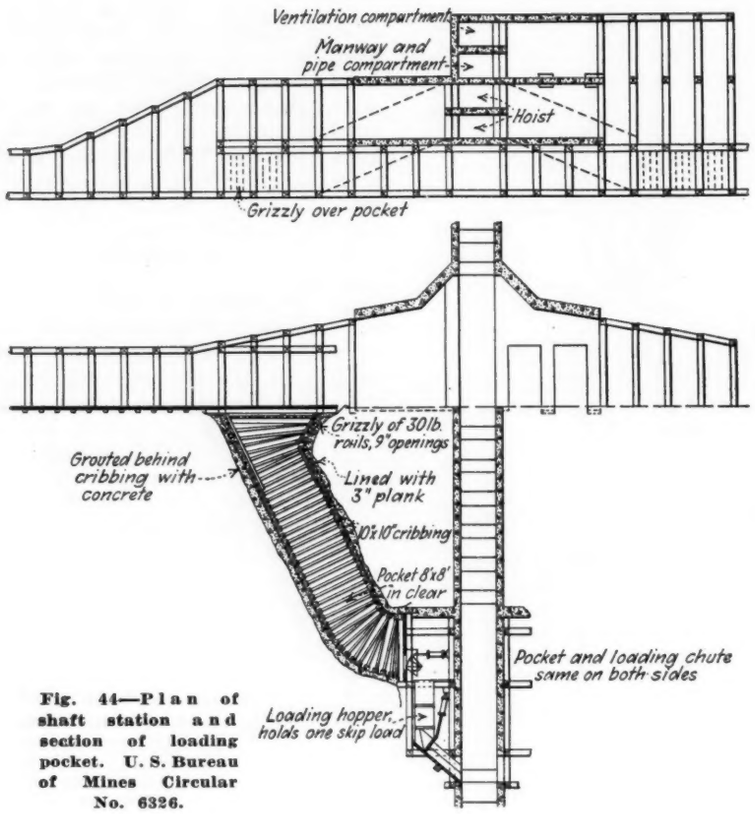
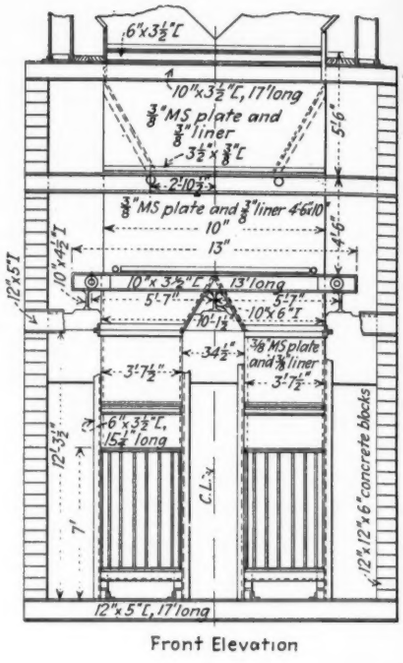
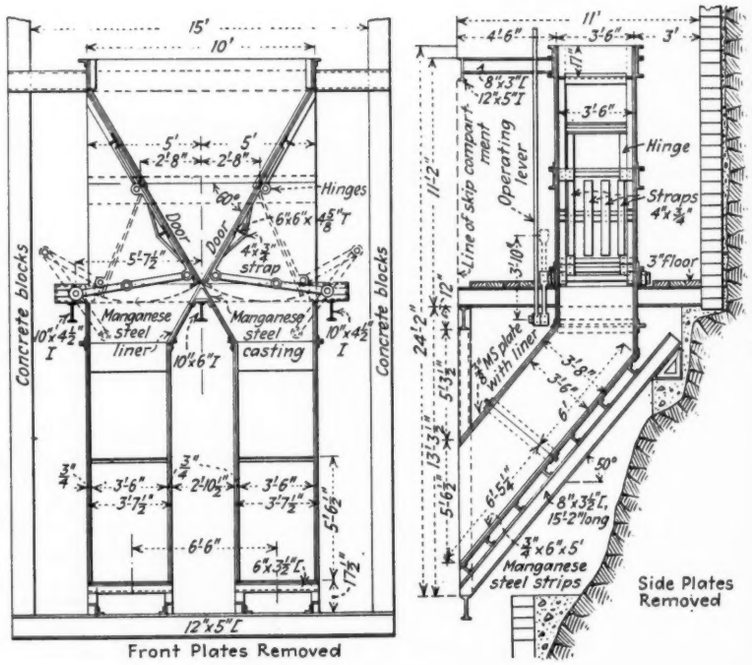

Ventilation compartment
Manway and pipe compartment
Hoist
Grizzly over pocket
Grizzly of 30 lb. rails, 9" openings
Grouted behind cribbing with concrete
Lined with 3" plank
10'x10' cribbing
Pocket 8'x8' in clear
Pocket and loading chute same on both sides
Loading hopper, holds one skip load

Fig. 44—Plan of shaft station and section of loading pocket. U. S. Bureau of Mines Circular No. 6326.

Fig. 45—Details of 200-cu.ft. two-door measuring pocket, used by Mufulira Copper Mines in skip-loading arrangement illustrated in Fig. 42





ings, after the box has been overturned onto a platform truck. The advantage of the method is that the guides do not have to be removed, but this is offset by the time required to change bearings.

The fourth method is by means of switch tracks. At inclined shafts which have no back runners, this is easily accomplished by means of a movable section of track, one end of which fits on top of the rails in the skip road. In one arrangement the rails are hinged at the lower end, and the upper end is raised and lowered by air cylinders or a small hoist. Another plan is to have the switch rails mounted on a truck, which is moved forward and back on a track. The procedure in this form of operation is as follows: The skip is hoisted above the point of contact and the switch rails are put in position. Then the skip is lowered and runs by gravity to one branch of a track, on the other branch of which the cage is standing. The hoisting rope is then transferred from skip to cage, and the process reversed. Time required is 2½ to 3 min. The exchange can be made on surface or at a lower level, whichever is the more convenient.

In vertical shafts, a somewhat similar arrangement can be used. The exchange is made in the headframe or below the collar of the shaft, where additional room has been provided. A section of the guides is hinged at the upper end, and the lower end is swung by means of an air cylinder to one side in line with auxiliary guides, acting in the same way as a stub switch. The skip is then lowered on the auxiliary guides. The movable guides are then swung into line with other guides, on which the cage is hanging, the hoisting rope is transferred to the cage, and the process is reversed. Making the exchange below the collar of the shaft has the advantage of keeping the idle skip or cage out of the way, but it is not as convenient with respect to inspection and repair as when done on surface, and the additional excavation adjacent to the shaft is expensive.

Spill.—In loading skips a certain amount of spill always takes place. This is especially true in shafts where the amount put into the skip is not measured mechanically, but is left to the skill and judgment of the man on duty.

Overloading is responsible for the greatest amount of spill.

Various devices have been used to prevent spill. The Kimberley type of pocket door acts as a chute cover, and sometimes an auxiliary hinged lip is provided, which bridges the gap between the skip and the bottom edge of the chute. A somewhat similar movable lip, which is interlocked with the operating levers, is shown in Fig. 40.

In the United States, dependence is customarily placed on the velocity of the ore, as it is discharged into the skip, to bridge the gap below the chute, and the amount of spill at this point is relatively small.

One of the best methods of preventing spill at the chute mouth is to install, just below the pocket, a pair of plates with tracks, similar in construction to those on the dump plates in the headframe, but of different shape, which engage the rollers on the sides of the skip box, and tilt the box forward until its front edge is 3 in. inside and underneath the lip of the chute. When the skip is hoisted, the box is pushed by the rollers back into its normal position.

Next in importance to prevention of spill is the provision of some means by which spillage can be easily hoisted. If the shaft has a separate cage compartment, the skip roads below the pocket are cased off from the cage road by a substantial partition, forming a pocket, and at the bottom of the shaft a small station is cut, and a chute is built through which the spilled dirt in this pocket can be drawn off into a car. This car is hoisted on the cage to the level above, and is dumped into the skip pocket. Pockets of this sort are shown in Figs. 36 and 38.

Another arrangement is to drive an incline from the spill pocket to the level above, and to hoist the spill dirt in a small skip or car by means of a small auxiliary hoist, and to dump it into the standard tram cars on the level. By this means spill dirt can be hoisted during the regular hoisting period, without interfering with hoisting operations, and can be disposed of without delay or inconvenience. It is probably the best method to follow in shafts of large capacity, in which a large tonnage is to be hoisted from the bottom level.

If the shaft has no cage, a method sometimes used is to inclose one skip road only to form a pocket, and to divert the spill dirt from the other skip road into this pocket by means of an inclined door. When spill dirt is to be hoisted, this door is raised to a vertical position, the skip above lowered, and the dirt from the pocket is drawn off through a chute into this skip.

Another device for catching spill is the spill skip, an auxiliary skip, which stands in the shaft just below the loading position of the real skip. It is usually a box, which runs on the guides and has a slanting bottom and a door facing the skip pocket. When the spill skip is full, it is attached to the empty skip above it, and is hoisted to a point just over the skip pocket, into which it is dumped.

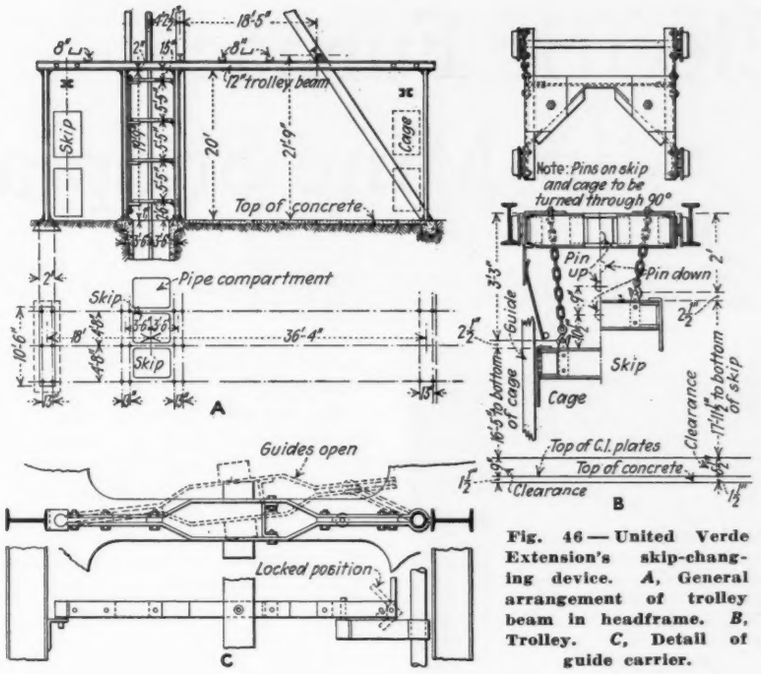


Fig. 46 — United Verde Extension's skip-changing device. *A*, General arrangement of trolley beam in headframe. *B*, Trolley. *C*, Detail of guide carrier.

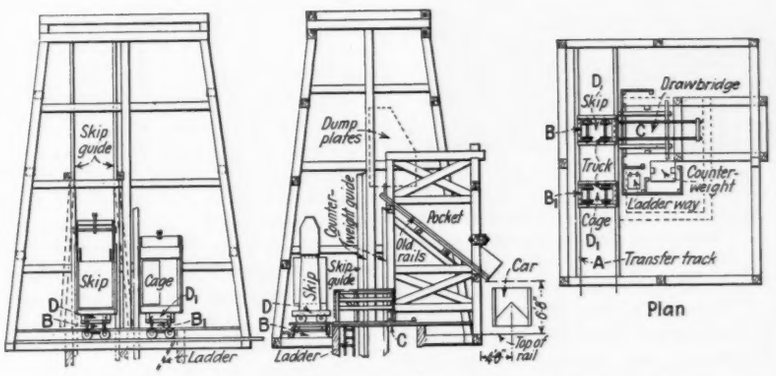


Fig. 47—Skip-changing device using transfer trucks. Cliffs Shaft mine, Ishpeming, Mich.

Theoretically, the spill skip is an ideal means of solving the problem of spill in loading, but it does not work out as well in practice as in theory. If allowed to become overloaded, delay and difficulty are experienced in getting it up, and, whenever one skip is hoisted too high in the dump, the opposite skip wrecks the spill skip in that compartment. For these reasons, spill skips have been discarded in a number of mining operations. Its advantages are its low first cost and the fact that it does not require a deep skip pit.

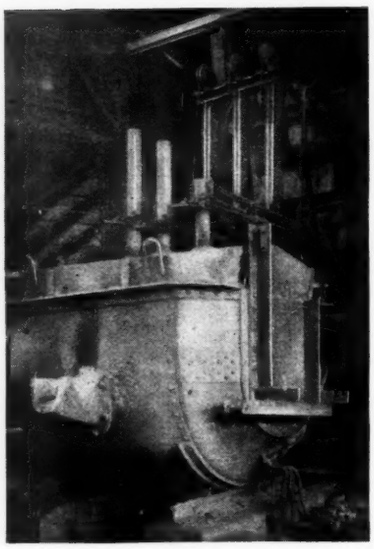
Conclusions—The foregoing discussion discloses a great lack of uniformity in skip sizes and skip design and in skip-loading devices. Both operators and manufacturers of mining equipment would profit if a few standards could be agreed upon. Opportunity exists for constructive work in this particular.

Furthermore, some of the newer devices described show a distinct advance over former practice. Rarely, however, are all the good ideas to be found in any one installation. This is partly due to the differences in local conditions. The idea of cutting off the ore stream entering a measuring pocket by means of an undercutting or rising gate, so that exactly the same volume of ore is loaded into the skip every time, could be generally applied. The double-discharge measuring pocket removes most of the difficulties attendant on separating different grades of ore underground.

For the sake of economy of operation and reduction of capital expenditure, the entire output of a mine should, wherever possible, be hoisted through one shaft. Careful planning of the methods used for filling the skips will usually make possible a large output without excessive hoisting speeds.

Electric Furnaces in Mine Shop and Foundry

A. H. Hubbell
Associate Editor



Greene arc furnace used for foundry work by Britannia Mining & Smelting Company, Britannia Beach, B. C.

ASIDE from its primary metallurgical applications, the electric furnace has made its entrance into the mining industry in shop work and related operations in four ways: for melting scrap in foundries; for heating drill steel preliminary to forging it; for heat-treating or tempering drill-steel bits after each forging; and for heat-treating or normalizing drill steel after a varying number of resharpenings in order to restore the quality of the steel and hold breakage in the bar to a minimum.

Whatever be its application, the electric furnace tends to reduce costs through facilitating precise control of temperature and giving uniform results. For foundry work, especially where alloys of varying compositions are being made, this is important; also in connection with sharpening steel, where the temperature of forging or heat-treating determines the length of service that the bit will render. In normalizing, the close control of temperature necessary is practicable only with electric heating. A further advantage of electric heating is its cleanness and convenience.

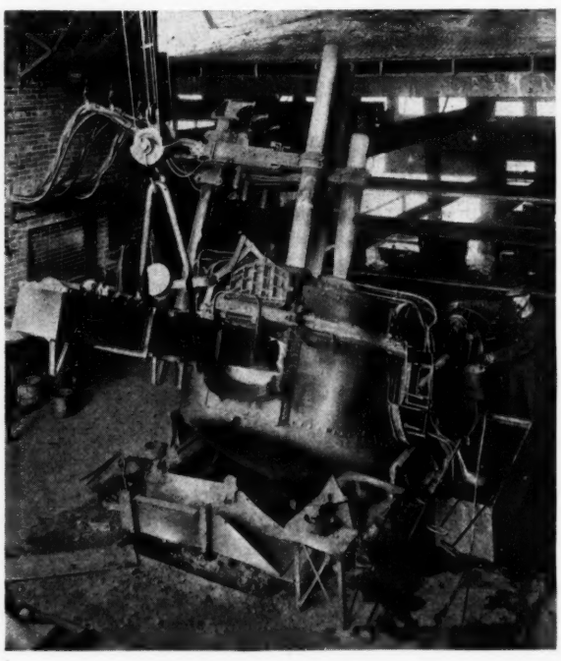
Because of these advantages and the normal tendency of industry to do things in the electrical way, if cost permits, the application of the electric furnace by mining companies may be expected to widen.

Melting Furnaces—These have thus far been of interest principally to mining and quarrying companies of medium or large size rather than to smaller enterprises, which have rarely boasted a foundry. The ever-increasing use of welding and cutting with gas or electric arc, however, makes it possible for smaller companies as well, with the aid of an electric furnace, to convert once unsightly scrap piles into castings for a wide variety of renewal parts at a saving. To those companies already equipped with a foundry and now using a cupola, the electric furnace offers the possibility of cutting costs. Cost of electric power and the quantity of power available will frequently be determining factors. Some typical installations of electric melting furnaces in the mining field are here described.

The Consolidated Mining & Smelting Company of Canada, at Trail, in British Columbia, is using a 3-ton Greene electric-arc furnace, rated at 2,200 kw., at its Tadanac plant, for melting scrap to make steel. At the same plant it uses also a 75-kw., resistance-type Bailey brass furnace for making miscellaneous non-ferrous castings. Other electric furnaces, to be mentioned later, are used in sharpening drill steel.

Britannia Mining & Smelting Company, Britannia Beach, B. C., has a 600-kw. Greene arc furnace in which it normally makes renewal parts, such as roll shells, weighing as much as 6,000 lb. each. It also makes hard-iron grinding balls, as well as all other castings required for mine and plant. This furnace is shown in an illustration. It operates directly from a 220-volt, 3-phase line, or a 440-volt, 3-phase line, with the aid of a Greene voltage-control apparatus. According to A. E. Greene, the inventor, a foundry in Vancouver, B. C., has made two 8½-ton (cleaned) crusher jaws, requiring approximately 21,000 lb. of steel scrap, in one of his 3-ton furnaces using approximately 1,100 kw. Energy consumed was about 504 kw.-hr. per ton of scrap melted.

Nevada Consolidated Copper Company, McGill, Nev., is melting scrap with a 1½-ton Moore 'Lectromelt electric furnace, made by Pittsburgh Electric Furnace Corporation. This unit, a photograph of which is reproduced, is used for producing grinding balls, liners, and other castings of steel, cast iron, and various alloys from scrap, of which the company has a large amount on hand. It replaces a cupola, formerly used, to which it has proved superior for producing the steel and alloy castings. In general, it has made cost reduction possible. Normally, it is run at its rated capacity of 1½ tons. At times special heats up to 4 tons are made for large castings. The furnace takes a peak load of about 1,200 kw. Normal power consumption is about 750 kw. per ton of finished casting.



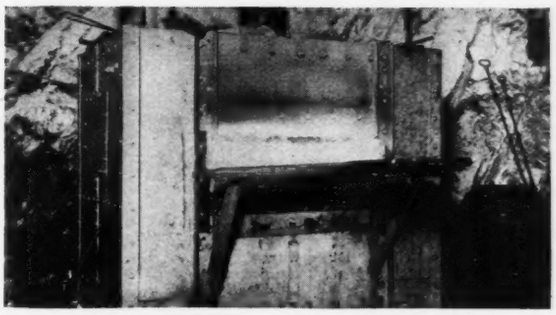
Moore 'Lectromelt electric furnace, used for foundry purposes, Nevada Consolidated Copper Company, McGill, Nev.

Power is relatively cheap, being produced in the company's own modern power plant.

Calumet & Hecla Consolidated Mines Company, Calumet, Mich., is using on experimental work a 3½-ton Heroult-type 3-phase furnace. This was formerly used in the foundry for making stamp shoes. It has a current consumption rating of 500 kw. per ton of cold metal.

Furnaces for Forging and Heat-treating Bits—Electric forge furnaces have an additional advantage, as compared with melting-type furnaces, in that, under conditions where a smoke- and gas-producing furnace would be unsuitable, they make it possible to attack and conquer the problem of distributing drill steel in a mine by installing the sharpening shop underground. By bringing the place where the steel is sharpened nearer to the places where it is used, the work of distribution is simplified. Layout of mine workings may be such as to rob this scheme of most of its advantage. Where layout is suitable, the only other obstacle is the possible safety hazard caused by introducing a furnace underground. Furnaces of any type, whether heated by oil, gas, coal, coke or electricity, normally present a fire hazard if installed or operated carelessly. All the types mentioned, save the electric, present an additional hazard in that they produce noxious gases which must be disposed of in some special way, unless the ventilation of the workings is exceptionally good. This difficulty is best obviated by use of the electric type.

For heating drill steel preliminary to forging, at its Sullivan mine, Kimberley, B. C., Consolidated Mining & Smelting Company of Canada in 1930 installed a Verdun Cutts electric furnace, supplied by General Electric Company, Ltd., London, England. This was used underground. According to its rated capacity, it will heat 800 to 1,000 1¼-in. hollow-round steels per eight-hour shift. The price, delivered at Kimberley, was $6,615, including all

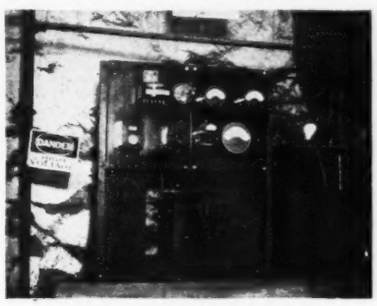


One of the underground electric forge furnaces used for drill sharpening at Sullivan mine of Consolidated Mining & Smelting Company, Kimberley, B. C.

electrical equipment, which comprised a 50-kva., 2,200-volt transformer having necessary taps for giving voltages from 120 to 60 at 7.5-volt intervals; also switchboard instruments, automatic temperature controller, thermocouple, current transformers, and other related apparatus, including spare electrodes and a supply of resistor material.

The following year, the Consolidated company built two smaller furnaces, of the same design save for minor

Side view of underground forge furnace, Sullivan mine



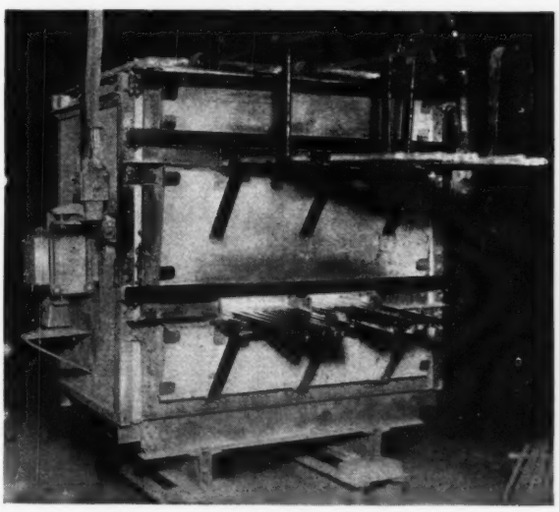
Electric control equipment for underground forge furnace at Sullivan mine

changes made to meet local conditions, such as altering the transformer wiring to give either full or half voltage on each tap. One of these is shown in a photographic reproduction. They were installed to avoid the necessity of otherwise having to use the surface plant whenever the large furnace was down for repair. These furnaces are operated at 1,050 deg. C. and are used for both sharpening and tempering. The Carbofrax troughs now being used are made by the Carborundum Company. The resistor is No. 9 granular graphite supplied by the Electric Furnace Company, Salem, Ohio. Refractories used are Johns-Manville Sil-O-Cel powder and brick.

More recently, a further change has been made in the design of the small furnace, the opening being lengthened and longer troughs being used, so that each furnace will keep two drill sharpeners supplied.

Through the courtesy of Mr. S. G. Blaylock, managing director of the Consolidated Mining & Smelting Company, costs of sharpening drill steel with the aid of electric forge furnaces and oil-fired forge furnaces, respectively, are presented in Tables I and II. The total unit costs per piece of drill steel are $0.0762 for oil-fired furnace operation and $0.0805 with the electric furnace. In the former, however, which covers the first half of the boom year 1929, almost twice as much steel was sharpened and repaired as was handled in the first half of the depression year 1932. This factor considered, the electric furnace is seen to be the more economical of the two. Moreover, inasmuch as it has to be kept at an operating temperature during short shutdowns, one-third more steel could have been heated in the first half of 1932, for the power consumed, had the mine not been working on reduced time.

In estimating the 1929 costs, certain approximations had to be made, according to the management. Charges for repairs to the oil furnaces and sharpeners not having been recorded separately, the furnaces were charged with 60 per cent of the total and the sharpeners with 40 per cent. Likewise, 10 per cent of the total labor required for repairing drill steel, making up new



Altshuler-Lantz electric forge furnace, used for drill sharpening at Pachuca by Cia. Real del Monte y Pachuca

Type-O Westinghouse lead-bath furnace, such as those installed at Pachuca for heat-treating drill bits after sharpening

steel, sharpening and tempering was charged to the first and second items and the remainder to sharpening and tempering.

By thus sharpening its steel underground, which is made possible by adopting the electric furnace, the company no longer needs to keep two shops, one at the upper mine and one at the tunnel. Steel transportation costs, moreover, have been reduced and the number of nippers required has been cut by half.

Electric forges for both forging and heat-treatment of drill-steel bits have been in service for several years at two central shops of the Real del Monte company, at Pachuca, Mexico. The larger shop serves mines normally requiring almost 8,000 bits per day. The other has half the capacity of the first. Since the two shops were built, they have sharpened over 8,000,000 bits. In each of them, heating for forging is done in resistor-type electric furnaces, designed locally by H. I. Altshuler and G. B. Lantz, and patented under U. S. Patent No. 1,831,054. The temperature is automatically controlled within a range of 50 deg. F. Power consumption is ¼ kw.-hr. per bit treated and carbon-resistor material consumption about 30 lb. per week. Each furnace will hold 120 pieces of 1-in. steel and has a maximum capacity of 200 bits per hour. One of the furnaces is shown in service in one of the halftones on p. 443.

The steel is heat-treated in Westinghouse Type-O 220-volt lead-bath furnaces, temperature being controlled within a 20-deg. F. range, that of the electric element being kept at 1,900 deg. F., this giving a bath temperature of 1,460 deg. F. Each furnace is rated at 39 kw. and has a capacity of approximately 200 heat-treated bits per hour.

Cost of sharpening at Pachuca is approximately 3c. per bit. Before the central shops were built, when oil-fired furnaces were used, the cost per bit was approximately twice this figure, owing among other things to multiplicity of supervision and the higher cost of fuel oil as compared with that of electricity.

Use of detachable drill bits furnishes another opportunity for the application of the electric furnace. The outstanding instance is at Butte, where the Anaconda company uses two types of Westinghouse furnaces for heating its Hawkesworth bits. These are first annealed in a Type H-75 box-type furnace and then ground. They are then given a double heat-treatment in a battery of J-25 furnaces, the hardening consisting of pre-heating in a lead bath to 1,100 deg. F. and then finishing the heating in a cyanide bath at 1,500 deg. F., after which they are quenched as a final step.

Another application of the electric furnace, and one of interest to any operator mining a soft material, was described by A. F. Brosky in the July issue of *Coal Age*. The Old Ben Coal Corporation, in Illinois, is retipping its cutter bits with a tungsten-carbide alloy, after reforging them in a sharpener. The bits are then heat-treated in an electric furnace, shown in one of the illustrations and made by the Hevi Duty Electric Company. After the hard-facing is applied they are quenched, then heated in the furnace to 1,490 deg. F., and held at this temperature for ten minutes, after which they are cooled in a water bath, then re-heated to 775 deg. F. and held there

Table I—Electric-Furnace Repairs and Operation

1932	Number of Steels Sharpened and Tempered (a)	Labor Costs	Labor for Repairs	Material for Repairs	Material for Operation	Power, Kw.-Hr.	Power Cost	Total Cost	Cost per Steel
January....	14,019	$837.26	$6.19	.....	$49.54	13,440	$73.92	$966.91	$0.0689
February...	17,295	1,096.05	38.25	$130.33	49.54	19,920	190.56	1,423.73	0.0828
March.....	20,914	1,260.34	10.69	154.06	148.62	20,400	112.20	1,695.91	0.0801
April.....	17,292	1,142.28	4.50	.....	99.08	17,760	97.68	1,343.54	0.776
May.....	16,406	935.48	47.77	226.41	98.30	18,960	103.18	1,411.14	0.0860
June.....	11,865	704.90	15.19	51.82	180.07	17,040	93.72	1,045.70	0.0881
Totals.	97,791	$5,976.31	$122.59	$562.62	$625.15	107,520	$590.26	$7,876.93	$0.0805 (b)

(a) Steel sharpener wage, 1932 — $5.28. (b) See text for comment.

Table II—Oil-Furnace Repairs and Operation for First Half of 1929

1929	Number of Steels	Gallons Fuel Oil	Cost Fuel Oil	Operating Material	Repair Material	Labor Repair	Steel Sharpening and Tempering Labor (a)	Total	Per Steel
January.....	31,566	1,127	$118.33	$2.13	$21.45	$62.13	$2,254.71	$2,458.75	$0.0778
February....	29,169	1,239	130.09	5.21	20.05	108.90	2,309.40	2,573.65	0.0882
March.....	30,843	1,077	113.08	2.13	28.30	73.95	1,969.73	2,187.19	0.0709
April.....	25,839	1,379	172.37	2.16	1.65	48.25	1,843.38	2,067.81	0.0800
May.....	36,231	1,429	178.62	4.32	58.10	78.20	2,060.67	2,379.91	0.0654
June.....	35,044	1,516	189.50	2.16	13.06	66.45	2,438.50	2,709.67	0.0773
Totals..	188,689	7,767	$901.99	$18.11	$142.61	$437.88	$12,876.39	$14,376.98	$0.0762 (b)

(a) Steel sharpener wage, 1929 — $6.08 per day. (b) See text for comment.

Two Westinghouse Type J-25 pot furnaces, such as are used at Butte for heat-treating Hawkesworth detachable bits after grinding

for 30 minutes, and finally quenched. Bit performance has thus been raised from 1.1 tons of coal per bit to as high as 12.5 tons with easy cutting and 9.8 tons with harder cutting. The cost was less than with ordinary unfaced bits.

Normalizing Furnaces—For normalizing drill steel throughout the bar to reduce breakage, heat-treatment is practiced, so far as known, by only one mining company, the Randfontein Estates Gold Mining Company, in South Africa. This company's shop handles 10,000 to 11,000 steels per eight-hour day. For normalizing, it uses a Verdun Cutts furnace, in which all steel is heat-treated approximately once a month, after eight to ten resharpenings. The steel is clamped in heavy copper terminals which grip it near the ends. For 1-in. hexagon steel a current of 12,000 amp. is used, the voltage varying (with the length of the bar) around 10. The steel is raised to its decalescent point—from 1,300 to 1,400 deg. F.—and allowed to cool in the air under definite conditions and quenched at the proper moment. By this practice, the company is said to have greatly reduced its purchases of new steel, by lessening breakage.

Considerations Attending Underground Installations—Before the installation of a furnace underground is attempted, consideration must be given the safety regulations, imposed by state, province, or county, to which the mining company is subject. Even where the law does not expressly forbid such installation, the state or provincial mine inspector, or his equivalent, should be approached to determine his attitude on the question. Usually, such officials have blanket authority to stop any practice which in their opinion is unsafe, even though the law is silent on the point. Specific facts, regarding underground furnace installations, elicited by inquiry with respect to the principal mining states in the United States, follow:

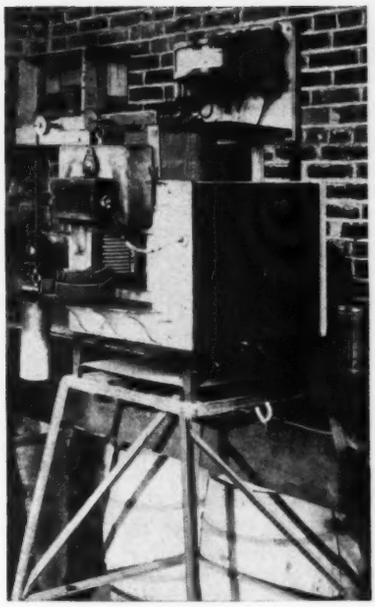
Alabama—Law does not cover. Practice does not exist.

Arizona—State Code gives Mine Inspector authority to rule on such equipment. Present inspector says: "It is not permitted." In his opinion, it is dangerous to the health of those employed underground.

California—Law does not specifically cover installations of furnaces underground. Industrial Accident Commission, however, prohibits use of fuel-burning engines or locomotives underground, with the apparent intent of preventing the fouling of mine air.

Colorado—Law does not forbid. A law exists governing underground installations of gas engines, which are not permitted unless conditions are perfectly safe.

Idaho—Informant knows of no law to prohibit, but apparently regards practice as unsafe.



Electric furnace made by Hevi Duty Electric Company and used by Big Ben Coal Corporation in sharpening cutter bits

Michigan—No mining code to govern such practice.

Minnesota—Law does not cover. Practice does not exist.

Montana—Law does not forbid.

Nevada—Law does not cover. Several installations of small coal-fired forges have existed underground.

New Jersey—Law does not forbid. At least one installation exists.

New Mexico—No law prohibiting.

New York—Law does not cover. If within a municipality, latter's law might cover. Law does cover storage of inflammable supplies and provides that every mine superintendent shall use every reasonable precaution to insure the safety of men, whether this is prescribed in the rules or not.

South Dakota—No law to govern.

Tennessee—No law prohibits. One company at least has an underground installation.

Tri-State District (Missouri, Kansas, Oklahoma)—Laws do not cover. Some installations in district. District Inspector for Oklahoma says: "Law does not cover the condition other than to leave it entirely to the discretion of the Inspector of Mines. Any furnace can be installed underground in metal mines of the State so long as its operation does not foul the ventilation. No reason why an electric furnace could not be installed and used."

Utah—No regulations or laws forbid installation underground of electric furnaces. State Metal Mine Inspector says he would "oppose any law or regulation giving definite authority for such installations, because definite fire and electrical hazards would exist, although remote. Any installation made would have to be foolproof."

Washington—Laws do not cover.

The official attitude in two provinces of Canada is as follows:

Ontario — Mining Act provides neither for nor against. Chief Inspector would decide with respect to fire hazard and removal of gases.

British Columbia—At least two installations exist which are permitted under conditions approved by Inspection Branch of Mines Department.

The foregoing indicates that in most instances the installation of electric furnaces underground would not be opposed by government officials if proper precautions were taken.

The attitude of mine executives toward the use of electric furnaces underground will naturally decide whether such application is to increase and how rapidly. Cost of power and its availability in sufficient quantity will exercise a strong influence, in many cases decisive. These two factors vary so greatly with locality that generalization respecting them is quite impossible.

In conclusion, the reasons recently given by Mr. W. J. Coulter, general superintendent of the Climax Molybdenum Company, in Colorado, for being interested in electric furnaces for forging and tempering steel, summarize the advantages of such application:

"We desire to locate our steel shop underground as close as possible to the center of operation, but do not feel that we can do it with the present furnaces, on account of smoke and gases.

"The main haulage drift is 3,000 ft. long to the point where it intersects the workings. If we are able to install a steel shop near this point of intersection, we could eliminate the nipping problem between it and the surface, thereby making a considerable saving.

"We believe that with electric forging furnaces and electric tempering furnaces we can turn out a much more uniform quality of drill steel than we are now able to make by heating steel in an oil furnace."

Among Contributors To This Issue

Raymond Anthoine is chief engineer for the Soc. de Mines d'Or de Kilo-Moto, operating placer and lode gold properties in the Belgian Congo. Statistical information, with a description of the methods used for recovery of gold in this little-known district, will be found on another page of this issue.

G. J. Young was formerly professor of mining and metallurgy at the University of Nevada; director of the Mackay School of Mines; professor of mining at the University of Minnesota; professor of metallurgy at the Colorado School of Mines. He is the author of standard textbooks on mining practice, published in England and in the United States.

Nathan K. Karchmer is a graduate of the Texas School of Mines and Metallurgy. Operating experience was gained with Chino Copper (New Mexico); A.S.&R. (Chihuahua and San Luis Potosi, Mexico); Mazapil Copper (Zacatecas, Mexico), and Cia. Minera de Santiago (Morelos, Mexico). Followed appointment as assistant mill superintendent with Patiño Mines & Enterprises, Llallagua, Bolivia. The United States Bureau of Mines next claimed Mr. Karchmer as research fellow at the Reno, Nev., station. Results of a recent experience in Russia, in the construction and operation of a flotation plant for the treatment of apatite, are given in this issue.

Harold R. Brisley (Universities of Arizona and California) has been a member of the research department of United Verde Extension for the past ten years.

Roy H. Poston is mining engineer for the St. Louis Smelting & Refining Works' operations of National Lead at St. Francis, Mo., with which company he has been connected in many capacities since 1909. He has on several previous occasions shared his experiences with readers of *Engineering and Mining Journal*

Lucien Eaton, who served for several years as superintendent of the Cliffs Shaft mine of Cleveland-Cliffs Iron, at Ishpeming, Mich., and as consulting mining engineer on the staff of Rhodesian Selection Trust, with headquarters in London, is spending the summer on the Marquette range in Michigan.

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Cornelius F. Kelley is in Europe.

Harlowe Hardinge is in California.

Thomas Pryor is in the Argentine.

J. Park Channing is at Houghton, Mich.

Dr. T. A. Rickard is now at Victoria, B. C.

Sydney H. Ball has returned to New York from Canada.

A. J. Bone has returned from Russia to the United States.

A. W. Furbank is visiting the gold centers of Ontario and Quebec.

G. Keith Allen has joined the staff of the British South Africa Company.

H. E. Clayton, of Austral Malay Tin, Taiping, Perak, F.M.S., is in England.

D. A. Thompson, on the staff of African manganese, at Nsuta, has returned to the Gold Coast Colony.

F. W. McLean, until recently mine superintendent for San Francisco Mines of Mexico, is at Grant's Pass, Ore.

W. B. McPhee, mill superintendent, New York & Honduras Rosario Mining, San Juancito, Honduras, is in Scotland, on vacation.

Colin Fraser, chairman of directors of Broken Hill South and Electrolytic Zinc, attended the Imperial Conference held at Ottawa recently .

Milo W. Crejci, formerly with Anaconda Copper, arrived recently in New York from Russia, after the termination of a contract for metallurgical work with the U.S.S.R.

Alexander Marcan, for many years director of the government laboratory at Bangkok, Siam, has retired and returned to England.

L. E. Sinclair has returned to London after resignation from the position of superintendent of the Tie Vaghi chrome mine, New Caledonia.

Col. Percy E. Barbour presented a paper on the economics of gold at the recent meeting of the Institute of Public Affairs held at the University of Virginia.

Horace A. Staples is chief engineer of the American Copper Products Division of the Phelps Dodge Copper Products Corporation, with office headquarters at 40 Wall St., New York, and plant at Elizabeth, N. J.

Leonard B. Haney, formerly on the staff of Broken Hill Associated Smelters, Port Pirie, N.S.W., has been appointed superintendent of the Dwight-Lloyd blast roasting section of the smelting plant at Mount Isa, Queensland.

L. D. Anderson, formerly chief engineer, United States Smelting, Refining & Mining Company, Salt Lake City, has returned to Russia as a member of the technical staff of the Freyn Engineering Company, of Chicago, supplying consulting service to Gifromez, U.S.S.R.

Dr. Richard A. Parker was recently admitted to the "Legion of Honor" of the A.I.M.E., joining many veterans who have maintained membership for 50 years. The award was made at a meeting of the Colorado section of the Institute, by Dr. Scott Turner, its president.

Dr. H. C. Parmelee, vice-president and editorial director of the McGraw-Hill Publishing Company, has been appointed a member of the National Research Council of the United States, on the Division of Engineering and Industrial Research.

P. M. Anderson, of the Union Corporation, Johannesburg, accompanied the government delegation of the Union of South Africa to the Imperial Conference at Ottawa, to act as unofficial adviser in behalf of the Transvaal gold-mining industry.

William Loeb, vice-president, A.S.&R.; **E. Daveler,** Utah Copper; and **R. E. Dwyer,** Anaconda Copper, are representing American Mining Congress in consideration of steps to be taken by the National Manufacturers' Association to curtail government competition with private enterprise.

Wylie Graham, of T. H. Graham & Sons, recently returned to New York from South America and left for California on July 14. For the past five years Mr. Graham has been general superintendent in charge of the rope-tramway system of the Northern Peru Mining & Smelting Company.

Capt. A. C. H. Gerhardi, interested in mining in British Columbia for several years, formerly in charge of the Toric mine and latterly of the Douglas Pine, was the victim of a distressing accident recently, whereby he lost both legs below the knee. He is reported to be recovering at his home in Vancouver.

H. L. McKinley is now on the staff of Buchans Mining, Newfoundland.

Capt. J. P. Hodgson, of Bisbee, Ariz., was married at Las Cresenta, Calif., on July 2, to Mrs. Clara W. Naylor.

George R. Fansett, of the Arizona Bureau of Mines, is visiting gold districts in California, Oregon, Washington, and British Columbia.

Lawrence Scotland, secretary of Tanganyika Concessions, has been appointed auditor of Union Minière du Haut-Katanga.

Howard James, formerly geologist for Granby Consolidated, at Anyox, B. C., has accepted a similar position with Pioneer Gold Mines, at Bridge River.

C. H. Marshall, until recently a member of the technical staff of Bell Telephone Laboratories, has joined the staff of Lucius Pitkin, Inc., as materials engineer.

A. A. Thomson, engineer to Sir Robert Williams & Co., has been elected a director of Tanganyika Concessions, Ltd., and of Union Minière du Haut-Katanga.

Charles D. Bocking, formerly manager of Butte & Superior, now manager of Granby Consolidated, Anyox, B. C., was recently in Butte, Mont.

Enoch Perkins, who has been engaged in professional work in Noumea, New Caledonia, for several years, has postponed until next year the visit he expected to make to the United States this fall. Commenting on an article in the *Journal,* he writes: "Diesel engines, while affording a suitable type of power for several different conditions in the United States, fit even better into conditions in isolated districts that are being opened up and in which we formerly had to have portable compressors or steam units. Many types and sizes of diesel-driven compressors are now available, as easily operated and maintained as compressors of the portable type. Until a diesel-driven portable compressor is placed on the market, the stationary unit will continue to have a large field for the type of service mentioned. Because of my experience with them in New Caledonia, I know that I should hesitate before installing any other sort of generating power unit elsewhere under similar or nearly similar conditions."

C. M. Smith, assistant professor of mining engineering research at the University of Illinois, who evinced interest in the description of an instrument in the June issue for the determination of an index of comfort in respect to atmospheric conditions, but who reported inability to secure, from an indicator constructed in the university laboratory, the results claimed, writes again as follows: "We found that our difficulty was not in failure to reproduce the size and shape of the bulb accurately but in our failure to evacuate it. . . . We made another one with a somewhat smaller large bulb and longer stem; and in comparing the operation of it with the original one we found it to pulsate more slowly. This indicates that the frequency of pulsation or sensitivity of the instrument is subject to differences in design. Each bulb must be standardized before results can be compared with those of any other."

Synchronous or Induction Motors

The Editor:

I was interested in the short article on page 348 of the June issue entitled, "Why Substitute Synchronous Motors for the Induction Type?" Of particular interest was the statement that the superintendent of one company maintains that the greatest economy is in the lowered repair bill. We ourselves, when considering this subject, have never neglected to credit the synchronous motor with certain real advantages resulting from greater clearance in air gap, as compared with the induction motor; but we have not before heard the same opinion expressed so decidedly by an operator. We all are familiar, of course, with the general sturdy construction of the induction motor and the record which it has made for itself the world over as a simple reliable form of drive in almost every conceivable application.

Incidentally, of the three applications mentioned, the only one for which the induction motor would be considered is the pump drive, rotary converters not being strictly a motor application, and air compressors already utilizing the synchronous motor to the almost complete exclusion of other types.

When thinking of synchronous motors in the mining industry, we are reminded of the situation at the Braden Copper property, where there are installed induction motors approximating in the aggregate 35,000 hp. and synchronous motors, 24,000 hp. This company's motto is "100 per cent power factor," and during normal operating times this ideal condition is closely approached.

R. S. SAGE,
Industrial Engineering Department,
General Electric Company.
Schenectady, N. Y.

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Tariff on Silver

The Editor:

It is needless to comment on the prevailing financial condition in this country or the causes that have brought it about, nor point out its effect on metal mining to a group of men as well informed as those responsible for the editing and issuing of your journal, or their failure to sponsor any constructive course to better conditions. Whatever influence actuates their course is best known to themselves. However, before the necessary readjustments can be made that will permit this country, and particularly the mining industry, to continue or resume a course of progress, many of the men and organizations that now assume to guide public opinion must be thrust aside.

If your publication under its present policy can continue as a leading exponent of publicity of the industry it aspires to represent, we shall view its continued success with interest.

COMPTON I. WHITE,
Whitedelf Mining & Development
Clark's Fork, Idaho. Company.

Felicien Cattier is now president of Union Minière du Haut-Katanga, in succession to **Jean Jadot,** decreased. Mr. Cattier has long been a director of this company, and also of Tanganyika Concessions, from which latter position he has resigned.

Obituary

M. S. Dean, traffic manager for Anaconda Copper; at the Mayo Clinic, Rochester, Minn., on July 8; aged 61. Mr. Dean was chairman of the committee formed during the War to direct the movement of all metals in the United States.

C. W. Hosmer (University of Utah); at Salt Lake City on July 14; aged 44. Mr. Hosmer, who saw service in France with the 318th Engineers, and who had operated mines in Idaho and Utah, was a member of the engineering staff of the Galigher Machinery Company, Salt Lake City.

H. J. Hardness; at Wytheville, Va., July 13; aged 77. Mr. Hardess, who was the son of Sir Charles J. C. Hardess, Ramsgate, England, was graduated from Freiberg in 1877 and came to the United States in the year following. He was at one time manager of the Omaha & Grant smelter at Leadville, Colo., and held other important positions in Colorado, Idaho, and the Eastern United States.

Brian H. H. Hooker (Clausthal, Freiberg, and Royal School of Mines); at Melbourne, Australia; sometime manager of Grube Elisa Alsace, Queensland Minerals Exploration, Ivanhoe Gold Mining (Kalgoorlie), North White Feather Consolidated, and other companies, with experience also in Borneo and Malaya. In 1911 Mr. Hooker was appointed to a position with the Commonwealth Bureau of Census and Statistics.

Van H. Manning, at Forest Hills, L. I., N. Y., on July 13, aged 70. After graduation from the University of Mississippi, he joined the staff of the United States Geological Survey. In 1910 he was made assistant director of the United States Bureau of Mines, and director in 1915. He gained special distinction for his foresight and initiative in organizing and directing an elaborate program of research in the manufacture of helium, reducing the cost from $1,700 to 39c. per cubic foot. He resigned from the directorship of the Bureau of Mines in 1920, to take charge of research for the American Petroleum Instituee, and he practiced in recent years as a consulting engineer.

William H. Kinnon, at Los Angeles, Calif., on July 15, following an operation for appendicitis; aged 66. Mr. Kinnon gained early recognition as metallurgist for the Colorado Iron Works, of Denver; and was associated while in Colorado with John F. Campion. In 1911 he joined the Mazapil Copper Company at Concepcion del Oro, Mexico, as superintendent of smelting; and in 1912 he became general superintendent of mines, smelter, and power plant for the Teziutlan Copper Company. Mr. Kinnon was at one time general manager of the 85 Mine, near Lordsburg, N. M., and brought this property into large-scale production. In 1916 he joined the Missouri Metals Corporation as general manager, and after the War returned to the West as a consulting engineer.

Flotation of Gold Ores Offers New Opportunities

INDUSTRIAL

PROGRESS

Max W. Bowen
Metallurgist,
Golden Cycle Corporation,
Colorado Springs, Colo.

FLOTATION applied to gold ores differs little from the flotation of other ores. In many instances it has replaced old methods, but more often it has been used in conjunction with one or more of these processes. Recently, in many large plants all over the world, changes have been made to either a straight flotation method or a combination of methods in which flotation plays an important part. Ratios of concentration as high as 30-50 to 1, and even higher, have frequently been attained. Flotation has possibly a wider scope, either in itself or in conjunction with other processes, than any other one process now employed in recovering metals.

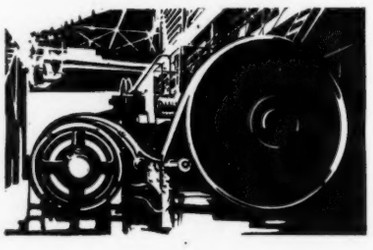
Gold ores may be classified into three general groups with reference to flotation:

1. Ores not amenable to flotation or treated in any way more readily by it. Ores of this class are not numerous.

2. Ores readily amenable to flotation and upon which a final tailing can be made by flotation alone. The step remains of reducing the concentrate to bullion. This class may be subdivided into (*a*) free gold ores, and (*b*) ores in which the gold is associated with base metal minerals, the latter being the most common. Among them are the ores in which the gold is closely associated with pyrite, arsenopyrite, chalcopyrite, and occasionally tellurides. Companies treating such ores include the Wiluna Gold and Lake View and Star, Western Australia, whose plants are employing flotation to concentrate the gold and in making a final tailing, then roasting the concentrate in Edwards roasters and cyaniding the roasted product. In Canada, numerous companies are following such practice or are planning to float their ores with subsequent treatment of the concentrate. Outstanding among them is the McIntyre-Porcupine, which floats its ore in Denver "Sub-A" flotation cells after a fairly coarse grind, regrinds all of the primary flotation tailing to approximately minus-65 mesh, and refloats, thus producing a very low flotation tailing. Cyaniding of flotation concentrate is often impracticable, on account of the presence of deleterious minerals, such as arsenic, bismuth, and antimony. Such concentrate must be shipped to a smelter for reduction to bullion.

3. The third class embraces ores requiring a combination of processes. Flotation is applied to such ores in several ways: Floating the refractory minerals (usually with a high ratio of concentration), giving a small percentage of the original ore special treatment and cyaniding the flotation tailing direct by ordinary methods. This has been done successfully in two different ways on the refractory sulpho-telluride ores of the Cripple Creek district. Here flotation was first successfully applied in plant practice in 1926 at the Independence mill, a cyanide plant of the Portland Gold Mining Company at Victor, Colo., by J. M. Tippett and M. W. Bowen. Flotation was done in mill solution, the cyanide content being approximately 0.25 lb. NaCN equivalent per ton of solution, and the lime approximately 0.20 lb. per ton of solution, with pine oil (10 per cent) and ordinary fuel oil (90 per cent). The fuel oil served to break down the natural froth tending to form in the pulp and the pine oil to form a froth of its own to carry the tellurides. This was true selective flotation, as the pyrite was thoroughly deadened by the lime and cyanide in solution. This concentrate was then combined with a table concentrate composed almost entirely of the pyrite, and the mixed concentrate given an intensive batch grind in mill solution in a tube mill. The fine grinding, combined with the reducing condition obtained in the air-tight tube mill, broke up the refractory compounds which carried gold, so that a very high extraction was obtained by cyanidation. The flotation and table tailings were subjected to ordinary cyanidation.

The second successful attempt was made at the Golden Cycle mill at Colorado Springs, Colo., in 1929. Here both tellurides and sulphides were floated in water, approximately 70-80 per cent of the gold present in the ore being recovered, with a ratio of concentration of from 20-35 to 1, and the ore being ground to pass 35-40 mesh. This concentrate was roasted in an Edwards roaster with crude ore and subsequently cyanided. The flotation tailing was dewatered and cyanided along with the roasted ore and concentrate. Recovery was high and roasting of approximately 95 per cent of the ore was eliminated.



Flotation is used also to remove cyanicides as well as other substances that are detrimental to subsequent cyanidation, including copper, carbon, or graphite and other carbonaceous materials. An example is the ore taken from the London mine, Alma, Colo., a part of which is now being treated at the Golden Cycle mill. The portion thus treated contains approximately the following: Gold, 1.5-2.25 oz.; silver, 1-1.50 oz.; lead, 1.2-2.3 per cent; copper, 0.25-0.75 per cent. Enough carbonaceous material also is present to preclude application of straight cyanidation even if no copper were present. A concentrate carrying practically all the carbonaceous substance, copper, and lead is first taken off and shipped to the smelter; next an iron concentrate is floated, and, as it carries practically no silver, is roasted with the Cripple Creek ores prior to cyanidation. The flotation tailing is then dewatered and given regular cyanide treatment. The ore can thus be treated in the Golden Cycle mill, whereas if it were not for the flotation unit, considerable difficulty would be met. This mill is handling also an ore carrying from 1 to 2.5 per cent copper in its cyanide plant by first floating the copper minerals and shipping the concentrate to the Leadville smelter.

Use of flotation in conjunction with table or other forms of gravity concentration is common practice, enabling the operator to recover by gravity concentration coarse gold that might escape the flotation unit, when grinding is very coarse.

Amalgamation may also be employed in conjunction with flotation when there is free gold, especially if it is coarse. Flotation following amalgamation will pick up gold associated with sulphide, tellurides, or other minerals not recoverable by amalgamation alone. Several plants in California are employing either one, two, or all three of these processes in treating ores containing free gold as well as gold associated with other minerals. One such mill in Colorado is treating an ore carrying free gold as well as gold associated with copper sulphides, pyrite, and other sulphides to a limited extent. All three processes—table concentration, amalga-

Abstracted from new Bulletin 3202, Denver Equipment Company.

mation, and flotation—are used. The bullion obtained from retorting is shipped to the Denver mint, and the concentrate sent to Leadville. Although this ore carries only about $4 gold, and the lead, silver, and copper content is low, the company has made a profit during the last year by treating approximately 750 tons per day.

Selecting the Flotation Machine—All types of flotation machines—pneumatic, mechanical, and a combination of the two types—are being used in floating gold ores. I consider the mechanical types with a series of cells better adapted to this work than are the pneumatic machines, because they give a better conditioning effect in the cells themselves, owing to the violent agitation in the mixing compartment, and also are better adapted to handle heavy sulphides at a coarser grind. Most mechanical types, as built today, are designed so that additional air can be supplied to the cells if necessary. Flotation of coarse free gold and mineral is made possible by the gravity-flow type of mechanical machine. In the flotation of oxidized or free gold ores, and to a lesser extent gold-bearing sulphide ores, if a high pulp level—that is, a shallow froth—is carried in the cell, better results are apparently obtained than if the reverse condition prevails—that is, low pulp level or deep froth. Rapid removal of the mineral froth by a paddle shaft is recommended. This is somewhat at variance with common practice in base-metal flotation, where a deep froth is usually carried. As mentioned, if the gold occurs in heavy sulphide, it is doubtful whether the carrying of a deep or shallow froth will affect results. The main thing is to remove the froth as soon as formed and not let it carry over from one cell to the next, because some of the gold may drop out of it, particularly if coarse or if cross-currents occur in the cell. Six or more smaller cells in series are always better than two or three large ones, in that they permit recleaning.

Selection of the proper machine is largely a matter of preference. Important points are: power consumption, maintenance, ease of operating and repairing, capacity per unit of space required, positive circulation, and flexibility of the machine. If the gold is freed by coarse grinding, the machine that will handle coarse feed without giving trouble should be selected.

Reagents—The reagents used in floating gold ores are practically the same as those used on other metalliferous ores, and are divided in three main classes. The following are most used:

1. Conditioning or corrective reagents: (*a*) Soda ash for alkalinity or for dispersing slimes. (*b*) Sodium silicate as dispersing and corrective agent. (*c*) Sodium sulphide or polysulphide for oxidized ores, acting as a corrective and sulphidizing agent. I have used a polysulphide made up by boiling 40 parts of caustic soda with 60 parts of sulphur, a very effective sulphidizer. Live steam was used to boil the solution, which was 10 per cent of the above combination in water. (*d*) Lime is sometimes used for alkalinity, but it tends to inhibit pyrite and other sulphides and to flocculate the slime. Lime, if added in minute quantities along the flotation unit, often overcomes evils of adding this reagent at one point in the circuit. Calcium sulphides and polysulphide are sometimes used as sulphidizing agents, but they have not been found as satisfactory in most instances as the corresponding sodium salts. (*e*) Copper sulphate is sometimes used on sulphide ores, especially if they are slightly oxidized or the sulphides are tarnished. It activates them just as in zinc flotation. Whether it has any effect on free gold ores is questionable. It may be detrimental.

2. Collectors and promoters: (*a*) Xanthates, made from lower and higher alcohols. (*b*) Aerofloats, both the liquid "15" and "25" and sodium Aerofloats. (*c*) Thiocarbanalid, either added dry to the grinding circuit or dissolved in some solvent such as ortho-toluidin.

3. Frothers: (*a*) Pine oils, probably the most universal. (*b*) Cresylic acid. (*c*) Liquid Aerofloats—both promoters and frothers. (*d*) Hardwood and coal-tar creosotes. (*e*) Tar oils, not commonly used in present-day practice. The first three are largely replacing creosotes, pine and coal tars, and intermediate products. Crude sulphur oil has been effective on free gold ores and on free gold in placer sands.

Construction and Operating Costs—The cost of building a flotation plant, like all other construction costs, depends largely upon the flowsheet required. It ranges from $500 per ton-day capacity, where a simple flowsheet will suffice, to $1,200 per ton-day capacity where a combination plant is necessary. Size of mill also is a factor. Use of portable mills with flexible flowsheets is recommended for developing prospects and isolated mines where tonnage does not warrant a larger permanent plant.

Cost of operation likewise varies according to flowsheet and capacity. Including taxes, insurance, amortization, workmen's compensation, and actual operating expense, it is rarely less than $0.75 per ton and may be as high as $1.50 or even more when treatment is complex or tonnage small. Flour and free gold from placer deposits may be floated at a low cost owing to elimination of the expense involved in crushing and grinding.

Factors to Be Considered in Designing a Flotation Plant for Treating Gold Ores.—(1) Can a final tailing be made by flotation alone, and, if so, how high a recovery and ratio of concentration can be made? If the ratio is high, shipment of the concentrate to a reduction plant will probably be cheaper than reducing it to bullion at the mill. (2) Can part of the gold be amalgamated before or after flotation, or, if the ratio is very high, can the concentrate be amalgamated in a grinding pan or other amalgamating device? (3) If a final tailing cannot be made by flotation alone, or in conjunction with amalgation, can tables or other means of gravity concentration recover the values that escape? (4) At what point in grinding are the values liberated? If very fine grinding is necessary, cyanidation at a much coarser grind may possibly be better. However, if extremely fine grinding is necessary and a high concentration ratio as well as high recovery can be obtained, then flotation will still be the better process. (5) If flotation alone, or, in combination with either or both amalgamation or gravity concentration, cannot make a final tailing, and cyanidation alone cannot be employed owing to the character of the ore, can preliminary flotation ahead of cyanidation be employed to advantage with the resultant lower cyanide plant chemical cost and possible greater recovery? Proximity of a railroad or reduction plant is an important factor in deciding the proper type of plant.

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Gas-Furnace Attains Temperature Exceeding Melting Point of Platinum

A TEMPERATURE of 1,850 deg. C. is easily obtained in the Degussa Lilliput furnace, a gas-heated laboratory furnace manufactured by Deutsche Gold- u. Silber-Scheideanstalt, Frankfurt-on-the-Main, Germany. Under favorable conditions a temperature of 1,900 deg. C may be reached, with ordinary illuminating gas, of 425 B.t.u.'s per cubic foot. Maximum temperature is reached in from fifteen to twenty minutes.

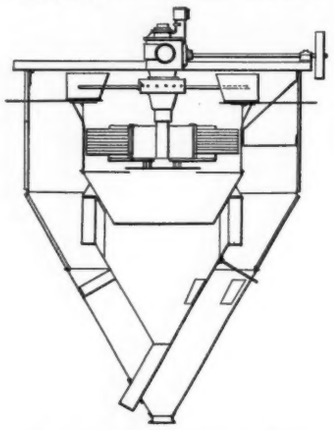
The furnace operates on the principle of surface combustion, in contact tubes possessing a highly reactive surface. Low resistance to the flow of gas and air, symmetrical distribution of flame, and highly effective insulation insure most favorable thermal conditions. High-grade corundum and magnesia are used for construction of the furnace interior, and the various parts of the furnace may be replaced in a few minutes. The furnace weighs 31 lb. net.

Furnaces of similar construction, for industrial use, for melting platinum

metals and alloys of high melting point, are also manufactured by the company named. Five different sizes are made, weighing 130 to 2,300 lb., and having an effective smelting volume ranging from 15 to 1,000 cu.in. A temperature of about 2,000 deg. C. may be obtained with these furnaces, after a heating period ranging from 1½ hours for the smallest size to 5 hours for the largest. They are equipped with magnesia or zirconia lining.

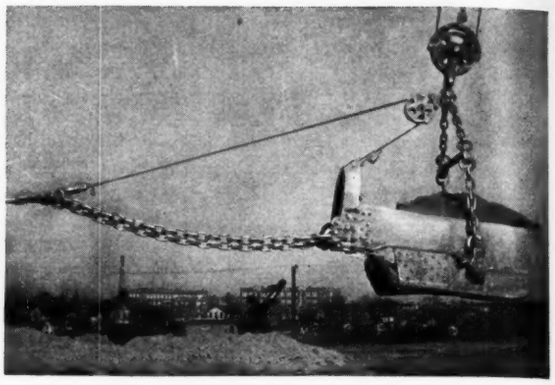
Air Separator Highly Efficient

Heavier construction and mechanical improvements are features of the most recent model of the Gayco air separator, known as the Gayco-Reliance. This separator is made by the Rubert M. Gay Division of the Universal Road Machinery Company, which has acquired the



Improvements have been made in the construction of this air separator

business of the late Rubert M. Gay. The unit embodies the well-tried principle of rejecting the coarse particles by means of a centrifugal sizing fan, as indicated in the drawing. The material is spread by a distributing disk, and practically all is carried up into the separating zone above the disk, where it is positively rotated by a fan having hundreds of steps of adjustment. Centrifugal action forces the particles to the outside of the upward-moving air current, the heavier ones reaching the outside of the air column before the lighter particles reach the opening in the chamber top. Positive adjustment can be made quickly for products ranging from 60 mesh to as fine as 100 per cent through 325 mesh.



This dragline bucket has been built to have exceptional strength and wear-resisting qualities

A New Dragline Bucket

A cut shows the new so-called "Red Arch" Type X dragline bucket produced by Bucyrus-Erie Company, South Milwaukee, Wis. This bucket is built in sizes ranging from ½ to 8 cu.yd. full measure, and is intended for general dragline work. It has been designed and built to give maximum strength and wear with minimum dead weight. Among its features is the "Red Arch," a one-piece annealed steel casting of great strength and minimum weight.

Aluminum hopper cars were recently placed in service by the Alcoa Ore Company to transport bauxite, sulphur, and soft coal. The corrosion-resisting qualities and light weight of aluminum will materially reduce equipment maintenance. Mine cars also are now being built of aluminum alloys for underground use.

INDUSTRIAL NOTES

Mine & Smelter Supply Co., Denver, Colo., has closed out its stock of mill supplies and electrical supplies at El Paso. The El Paso office will be continued as an engineering and sales office.

Worthington Pump & Machinery Corp., Harrison, N. J., will transfer and consolidate the designing, engineering, and manufacturing activities formerly conducted at its Cincinnati works with those of its Buffalo, N. Y., manufacturing plant. For the present the former plant's equipment will remain intact.

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BULLETINS

Oil Separators. Leavitt Machine Co., Orange, Mass., U. S. A. Catalog A, describing device for removal of air and water from compressed air.

Boilers. Foster Wheeler Corporation, 165 Broadway, New York City. Bulletin No. B-32-3.

Mining Machinery. Eastern Iron & Metal Co. Inc., Salt Lake City, Utah. General catalog.

Ball Bearings. Auburn Ball Bearing Co., 57-85 Clarissa St., Rochester, N. Y. Data book; ball thrust bearings.

Instruments. Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio. Bulletin 112; boiler water level recorders.

Instruments. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. Catalog 40; electrical resistance measurements.

Welding. General Electric Co., Schenectady, N. Y. Bulletin No. GEA-1546, supersedes GEC-93, welding electrodes and accessories.

Gears. Farrel-Birmingham Co., Inc., 415 Vulcan St., Buffalo, N. Y. Bulletin No. 425, Farrel-Sykes high-speed gear units.

Diamond Core Drills—Sullivan Machinery Co., Chicago, New York, London. Bulletin 85 R.B. "Sullivan Bulldog Safety Clamps."

Flotation — Bulletin, "Sawdust as a Flotation Reagent," on the technical application of sawdust and xanthate, obtainable from patentee, Joseph Lane, San Francisco del Oro, Chih., Mexico.

NEWS OF THE INDUSTRY

PACIFIC NORTHWEST

Placer Gold Source Discovered. Hecla Mining is reported to have taken over the Homestake claim, near the Union mine, at Grand Forks, B. C. The company will prospect by diamond drilling. . . . Announcement is made that the mother lode of the placer gold in the Bald Mountains, near Orofino, Idaho, has been found. . . . Scott Turner, director of the U. S. Bureau of Mines and president of the A.I.M.E., accompanied by A. B. Parsons, visited late in July the Coeur d'Alenes, Nelson, and Trail, B. C., where they attended a meeting with the Canadian Institute and visited the plants of Consolidated Mining & Smeling. . . . Drilling by Bunker Hill & Sullivan on the Brown-Lafors claims in the Slate Creek district is reported in Spokane to have indicated a substantial orebody of lead and zinc. The Brown-Lafors is part of the Leadhill group holdings in which Bunker Hill & Sullivan has a 50 per cent interest.

Oregon Reports Gold Development. W. F. Hayden, of Salt Lake City, is reported to be in charge of ambitious plans to develop two gold mining properties in southern Oregon. The ore is reported as free milling, in large quantity, and assaying from $2.50 to $3 per ton.

Alaska Juneau in June. In June, Alaska Juneau mined and trammed to mill 332,150 tons. Operating revenue was $281,000, or 84.6c. per ton; operating expenses, $154,500, or 46.51c. per ton; operating profit, $126,500, or 38.09c. per ton; interest received on current funds, less outside prospecting, $2,000, leaving $128,500 to surplus for the month.

Montana Gold Developments. Roy E. Miller, Inc., has taken over the properties formerly operated by the Jib Consolidated Mining, at Basin, Jefferson County. Mr. Miller plans to treat the dump of 40,000 tons, and later to unwater the Katie and East Katie shafts. The property consists of twenty claims, only three of which have been worked. . . . Little Ben Mining has been incorporated by the group of men operating the August mine, Landusky, Phillips County, under the form of a common-law trust. The property has been producing gold ore bringing from $7,000 to $14,000 per railroad car. The company also owns a cyanide plant. Increase in production of high-grade ore is planned. The mill is to be remodeled, for use on lower-grade gold ores. . . . Vosburg Syndicate, operating near Winston, under direction of John and Clinton Roos, shipped a 30-ton car of ore that assayed 4.75 per cent lead, 8.4 oz. silver, and $14.60 per ton in gold. Flotation tests are being run on the ore, and a mill is being planned. . . . American Smelting & Refining recently complete the installation of natural gas at its East Helena plant, from the lines of Montana Power. The gas will be used for smelting and plant-heating purposes.

ARIZONA

Several Gold Mills Planned. The Hayden smelter of A.S.&R. recently shipped to European points, via Los Angeles and the Panama canal, 49 carloads of blister copper. The total order was for 5,000,000 lb. . . . Phelps Dodge closed its Morenci branch on July 21. . . . The Monte Cristo mine at Constellation, 15 miles northeast of Wickenburg, is to be operated by Walter G. Clark, of Los Angeles, and associates. This mine was sold in 1926 by Ezra Thayer, of Phoenix, to C. C. Julian, the California promoter, for a reputed price of $1,000,000. A power line is laid to the mine, and the plant includes hoist, compressor, pump, machine shop, and eighteen camp buildings. C. D. Ryder, president of Federated Engineers, of Los Angeles, is one of those interested in the enterprise. Another mine to be reopened is the Climax, 14 miles south of Prescott. C. E. Mason and associates, of Phoenix, have taken it over under lease from the King Gold mining company. C. W. Steinman, formerly superintendent of the Gunsight mine at Ajo, will be in charge. Approximately 80,000 tons of $10 ore is said to be on the dumps and some ore is in the mine. A flotation mill is to be erected. . . . E. Ross Householder is getting the Roadside shaft in the Union Pass section of Kingman in condition for operation. The shaft has been cleared to the 100-ft. level and will be unwatered to the 300-ft. level. The 50-ft. level is being developed. The property is 4 miles east of the Katherine, from which the first bar of gold bullion made since operations were resumed was shipped. At Chloride, W. J. Loring has taken over the Pilgrim group, and is preparing to sample it. At the Diana, ten men are getting the mine ready for production. The company has leased the near-by Monarch mill. The Arizona Magma, also at Chloride, has unwatered the shaft, placed a pump on the 300-ft. level, and is erecting equipment for compressed air supply. . . . G. M. and S. L. Land have bonded and leased the Gold Standard, a lode mine near Dos Cabesas, to C. W. Gabrielson, former owner of the North Cananea mine, Sonora, Mexico. He expects to erect a 100-ton mill. . . . Max A. Stark, of Phoenix, and associates have taken a lease on the El Tigre mine, a gold property in the Harqua Hala district. They expect to build a flotation plant. C. W. Steinman is consulting engineer.

COPPER COUNTRY

Concentrator-Amalgamator Is Put to Work. Fifteen members of the senior class in metallurgy at the Michigan College of Mining and Technology, at Houghton, have left, in two groups, on a prospecting trip to gold territory north of Ishpeming, Mich. Equipped with machinery made at the college during their course of instruction, including concentrator-amalgamators invented by Prof. A. T. Sweet, head of the metallurgy department, and other essentials, they will camp out for two weeks, investigating the geology and doing general prospecting to determine the possibilities of a region which for many years has been represented as gold-bearing. They will penetrate a new country in which no work of a similar character has before been attempted. The party will be in direct charge of George Blair, an instructor in ore dressing at the college. The results of the work to be done will largely determine whether the geology indicates the presence of gold. . . . R. A. Cosgrove, of L'Anse, Mich., a graduate of the college, has left for Gold Creek, Mont., where he will test the concentrator-amalgamator for Milwaukee interests. . . . The party of Michigan Tech metallurgy students who have been investigating the Dahlonega gold district, in Georgia, and experimenting with a concentrator-amalgamator, have returned to Houghton, bringing with them samples, which they will assay and submit to extraction tests. They sampled a section of the district. On their return to Georgia, they will sample the entire district for Copps Development. The party used the concentrator-amalgamator to good advantage in Georgia, obtaining satisfactory results, and will continue working with this machine on their return. Two firms are negotiating for its manufacture. When it is placed, the royalty on the machines sold will go to the research fund of Michigan Tech. The machine was developed as a research project. . . . Quincy and Isle Royale are being kept free of water. The cost of pumping is considerable, but the openings and shafts are thereby kept in good condition, making resumption possible on short notice. . . . Calumet & Hecla is working only the conglomerate mine, producing rock from pillars and old stopes in upper levels of a grade that helps to keep the cost per pound of producing copper down to a minimum. At greater depth, in the bottom levels, the ore is comparatively low grade. Thousands of feet of new openings, however, have been made in the last few years, which provides ground for selection. The bed is of better grade to the north than below the haulageway under the old mine. An

extensive area on the lode, both to the north and below "A" and "C" shafts, should give Calumet & Hecla long life on the conglomerate. The yield should average as good as that of the amygdaloid rock on which all the other mines of the Michigan district are dependent. . . . Copper Range is working only the Champion mine, but is paying considerable attention to preparations for the opening of the westerly extension of the Baltic lode in Globe lands, a development which looks promising for the future.

Mohawk started on July 1 to ship its current production of mineral or concentrate to the smelter at Houghton, where it will be converted into refined copper. With the exception of 1,500 tons shipped in June, Mohawk has not sent any mineral to the smelter in more than two years. The concentrates are in storage at the Mohawk mill and at the idle Wolverine mill. Stocks there are estimated as equivalent to more than 30,000,000 lb. of refined copper. This is being held for a better metal price. Resumption of mineral shipping, which will be confined to daily mill production, probably means that Mohawk has a market for this output in refined copper. To meet prevailing conditions Mohawk announced an additional cut in wages on July 1, of 16⅔ per cent. This will give miners about $2 per working day. Wages of surface employes will be proportionately lower. While the mine is in daily operation, the work has been arranged to provide for all employes with dependents. The men are averaging about twenty shifts per month. The property will continue on the present basis as long as it can meet cost of operation.

UTAH

Utah Copper Resumes Operations. Operations were resumed on July 18 at the mine and mills of Utah Copper, at Bingham. Fifteen hundred men are being given fifteen days' employment per month by rotation. Production will be at the rate of 10,000 to 11,000 tons of ore daily. . . . Development of the Rio Tinto property at Mountain City, Elko County, Nev., has been taken over by International Smelting. The incline shaft is being widened to two compartments. When this work is completed, the shaft will be sunk another 100 ft. from the present bottom at 250 ft. Rich copper ore was struck last winter at a depth of 225 ft. After sinking 15 ft. a drift was driven 80 ft. in the deposit. Above Level 235 the ore is oxide; below that level it is sulphide. Five carloads have been shipped that assayed 40 per cent copper. . . . A 60-ton carload of ore, valued at about $119,000 in gold, was shipped this month from the Eureka Standard mine of the Tintic Standard, near Dividend, Utah. . . . A test shipment of 5,000 tons of low-grade gold ore from the Grand Central mine of Chief Consolidated is being made by A.S.&R. J. Fred Johnson is directing the work. If results prove satisfactory, a large tonnage may be moved, and an enterprise started that may prove of help in stimulating the mining industry of the region and the State.

CALIFORNIA

Favorable Report on Alleghany District. The peculiar concentration of gold in high-grade shoots of the Alleghany district, Sierra County, was the object of a study by H. G. Ferguson and R. W. Gannett, the results of which, recently published by the United States Geological Survey, should be of value in future development work. Areas in which physical conditions favored the fracturing of the vein prior to the introduction of the gold were found to be the most promising. Such fracturing is largely dependent on changes in strike or dip of the vein, and these changes are commonly found where the veins are close to masses of serpentine, at junctions of veins, and where the veins have been faulted prior to the introduction of gold. Another influential factor is the presence of early arsenopyrite, which has acted as a precipitant for the gold. Conditions are thought to be favorable for reasonable persistence of the high-grade ore in depth, and an optimistic view is taken of the outlook for lode mining there.

Construction Activities Widespread. Lakenan Investment is pushing plans for the reopening of the Spring Hill mine, alongside the Idaho-Maryland, at Grass Valley. The shaft of the Empress mine, in the same district, is to be extended from the present level, and work has already started. . . . A custom mill, consisting of breaker, stamps, concentrating tables, and amalgamation plates, will soon be in operation at the Crandall mine, near Ophir, Placer County. It will be operated by the Mine Owners' Association. . . . The new Knight hoist at the Argonaut mine, near Jackson, is in operation and facilitating sinking operations in the new shaft. . . . Amador Star, near Plymouth, is being equipped for an extended scale of operations. Additional mining and milling plant is on order. . . . The new mill at the Banner mine, near Oroville, is in operation; and progress is reported of the plan to transport gravel by rope tramway from the north bank of the Feather River, near Oroville, to a point at which the gold may be recovered and the residue dumped. . . . John Herman, of Los Angeles, is advising Ruby Mining on a method of treating the ore from the company's property near Bakersfield, and a mill will probably be designed and erected in the near future. . . . Shortage of water in the placer deposits of Northern California is causing suspension of work by the larger companies, but low water permits greater opportunities for hand work, thereby providing a livelihood for men and women who otherwise would be unemployed. . . . Mark L. Requa, well known California mining engineer, has been named as one of the committee to direct the campaign that has for its purpose the re-election of President Hoover.

NEVADA

Sustained Interest in Gold Mining. The new camp of Grapevine, 33 miles northwest of Beatty, is attracting attention and capital. In addition to four major operations, eight or ten small groups are operating in the district. . . . Nevada Consolidated has completed the installation of its third hydro-electric plant at Duck Creek. The water is conveyed through a 19-in. welded steel pipe. Completion of this unit gives the company a total of 1,300 kw.-hr. from hydro-electric plants. Another electric shovel has been purchased, to be put into operation at the Ruth pit in the near future. . . . The Mary mine, at Silver Peak, is supplying ore to keep four mills running, and shipping high grade to the Salt Lake smelters. The four mills are Hughs & Fanchini, 30 tons; Black Mammoth, 25 tons; Calavada, 40 tons; and Liberty Divide, 35 tons, which is to be enlarged to 100 tons. . . . The Buckskin mine, 16 miles west of Yerington, has been taken over by a group of capitalists from San Francisco, headed by H. E. Woodrich. A mill is to be installed, and machinery for mine and mill equipment is now being moved in. Diesel engines will furnish power for mill, compressors, and small equipment. Three concentrating tables, a Dorr thickener and classifier, and a hoist have been delivered. A ball mill is on the ground. Amalgamation will be employed at present, but will be displaced by flotation later. . . . Bradshaw, Inc., has declared another dividend of $10,000 from profits in treating Goldfield Consolidated tailing. This brings the total in dividends to $172,105.32. A yield of $30,418 resulted from the treatment of 31,000 tons in June.

CANADA

Gold Activity Maintained. Howey Gold, the lowest-cost gold mine in Canada, has now attained its objective—$2.50 costs on $4 ore. For the six months ended June 30, 157,000 tons was treated for a recovery of $600,000, or $3.80 a ton. The grade mined is a little lower than originally anticipated, because of enlargement of the stoping widths and lengths. . . . Eustis Mining, in the Eastern Townships of Quebec, which has operated continuously for 67 years, is likely to be closed on account of the United States copper tariff. For many years it has shipped its concentrates of copper and pyrite to points in the Eastern states. During 1932 a part of its pyrite flotation concentrate has gone to a paper mill at Three Rivers, to provide sulphur gas by the Freeman flash-roasting process. . . . McIntyre Porcupine Mines, with its new mill, new change house, and comparatively new shaft and hoisting equipment, is probably the best-equipped gold mine in Canada. The financial position is satisfactory, earnings for the fiscal year having been $2.65 per share; present surplus, $5,000,000. An important new vein system has been found to apex at about 3,600 ft. on the Platt Vet lot; a winze is to be sunk from the 3,750 level, with an objective of 6,700 ft., to explore it. . . . Ashley Gold Mining, expected to join the gold producers of Ontario in September with ore of $15 to $20 grade, has been finding more regular deposits on its present bottom level at 500 ft. than on the three levels above. The stoping width will not be over 4 or 5 ft. down to this level. Preparations are under way to open levels at 625 and 750 ft. . . . Dome Mines, the obsequies of which have been prepared many times during its 22 years of operation, is now enjoying a prosperous period. During the first half of 1932 its new mill treated 267,800 tons, with a recovery of $7.86 a ton, compared with $6.55 last year. This is attributable mainly to an improved ore supply, a new deposit of above-average grade having been opened on Level 13; but some slight changes in the mill made late in 1931 also helped. . . . A statement by J. M. Forbes, general manager of Siscoe Gold, gives recovery for the first six months of 1932 at $572,800 (including exchange premium), from 31,418 tons of ore. Mill heads, $16.34; tailing, 21c.; operating costs, $5.85 per ton. New sources of ore are indicated, he reports, especially on the 150- and 600-ft. levels. The shaft is now at 885 ft., and will be continued to 1,000 ft. Plans are being prepared for a probable mill extension during the early part of 1933. . . . As blister copper from Flin Flon is refined in Montreal and marketed overseas, the United States copper tariff is not likely to affect the mine's operations. Most of the zinc, refined at the mine, is also sold in Europe and Asia. The company is meeting its operating expenses and fixed charges, largely by virtue of gold recovered, which last year gave an income of $1,750,000. . . . Pronouncements of the delegates at the Imperial Economic Conference in Ottawa have indicated, almost uniformly, that trade arrangements in view are to be based on a lowering of present intra-Empire tariffs, rather than upon any increase of tariffs against the rest of the world. The spokesmen for Great Britain, Canada, and other Dominions have indicated clearly that their respective governments have no intention to shelter inefficient industries behind tariff walls, at the expense of the public.

BRITISH COLUMBIA

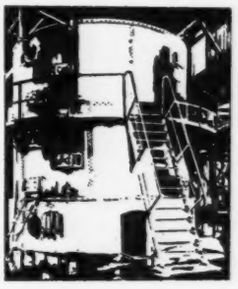
Empire Copper Market Sought. Representations by British Columbia copper producers to the Dominion Government request that policies be advocated at the Imperial Economic Conference to insure preferential Empire markets for copper of Canadian origin, irrespective of where it may be refined. Copper produced by Granby and Britannia cannot now be sold in the United States, because of the tariff. A brief submitted to the Dominion Government points out that the British Columbia producers have no alternative to shipping copper products to the United States to be processed, the cost of transportation of concentrates to refineries in Eastern Canada being prohibitive, and reserves do not warrant the establishment of a local copper smelter and refinery. . . . Consolidated Mining & Smelting has curtailed lead production to 85 per cent of normal capacity; of zinc, to 45 per cent. Production returns for the second quarter of 1932 show an output of 30,929 tons of lead and 17,118 tons of zinc, compared with 36,678 tons of lead and 30,037 tons of zinc during the corresponding period of 1931. . . . Cariboo Gold-Quartz Mining, operating near Barkerville, is installing a mill. During the past few months six additional veins, varying in width from 2 to 6 ft., assaying well in places, have been penetrated by a main crosscut tunnel. A government report states that, assuming the sampling of the numerous ore showings to have proved satisfactory, "the time for the erection of a mill seems ripe"; and adds "while it cannot be said that a large tonnage is actually 'blocked out' at this property, the large number of veins of good width exposed indicates a liberal factor of safety." . . . Bralorne Mines, operating the Lorne Mine, in the Bridge River district, reports that since the inception of milling operatons in February last gold to the value of $157,475 from 11,119 tons of ore milled was recovered up to the end of May. The original Lorne company is now to be voluntarily liquidated, and the shareholders are invited to exchange their shares for Bralorne stock. Development of the mine is proceeding. Sufficient ore is assured to maintain milling at 100 tons a day for seven months.

MEXICO

Mexican Copper for European Refineries. Because of United States import levies on copper, El Boleo Mining Company, operating in Lower California, will market its metal in Europe. The company has sent the first shipment, of 800 metric tons of copper, to Guaymas, for shipment to San Francisco, Calif., whence it will be re-exported to Europe. . . . Four placer gold claims have been leased by Robert Carlisle to the Santo Domingo Mining. The company has started exploration. The claims are along the Rio Conchos, Aldama municipality, Chihuahua. . . . More than 400 claims for compensation against mining companies have been filed with the Federal Board of Conciliation and Arbitration, and with other state labor boards, by miners suffering from silicosis and tuberculosis, which the new federal labor law classifies as professional ailments. The majority of the claims were lodged by miners in the Pachuca district mining zone. The Ministry of Industry, Commerce and Labor has established an agency in Pachuca for the free medical examination of miners who have claims for professional ailments and to assist them in presenting their cases for compensation. . . . Suspension or reduction of activities by mining companies, principally in northern Mexico, are considered to contribute to a deficit of 15,000,000 pesos the National Railways of Mexico will report this year. . . . In May, San Luis Mining shipped from its mines at Teyatitla, Durango, to its refining plants at Selby, Calif., 107,453 kilos of gold and 6,035,648 kilos of silver. . . . Cia Miñera de Mercurio, S. A., a Mexican enterprise operating eight mercury mines near Huahuaxtla, Taxco municipality, Guerrero, has asked the Federal Board of Conciliation and Arbitration for permission to suspend operations on the ground that low mercury prices make activities unprofitable. The board's inspectors are making a study of the petition.

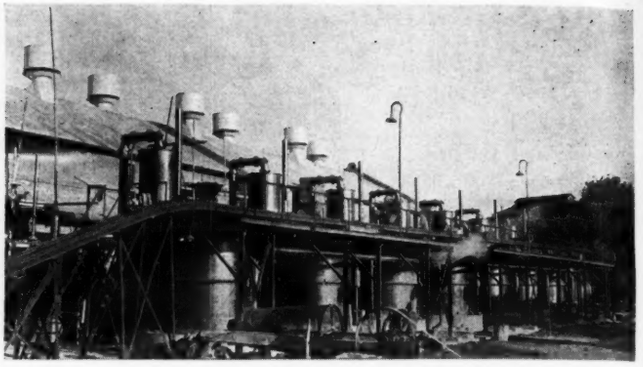
JAPAN

Export Copper Market Sought. According to U. S. Department of Commerce reports from Tokyo, the Japan Copper Producers' Association is considering the exportation of 2,000 tons of copper per month. A trial shipment of 100 tons to South America has been made, competition there having been avoided hitherto by Japanese producers because of the financial situation and control by American producers. Exports to countries other than Japan in the Far East are averaging about 500 tons per month. Following the gold embargo last December, a boom was created in the copper market, which subsided, and a depressed condition now prevails. At the peak of production a monthly output of about 6,400 tons was made; this was reduced to 6,000 tons, then to about 5,800 tons, the present rate. Even at this output, surplus stocks are rapidly mounting, and are expected to have reached 6,500 tons by the end of June.



PHILIPPINE ISLANDS

Gold Output Promises Increase. Benguet Consolidated Mining and Balatoc Mining, Manila, P. I., announce ore reserves for Benguet as of July 1, 1932, as 491,850 tons, of an average of $14.59 per ton; and for Balatoc as 485,000 tons, at an average of $16.20 per ton. Production for the first half of 1932 for Balatoc should be close to $1,000,000, and for Benguet should be about $990,000. Benguet's production might have reached $1,000,000 had it not been for the mine fire that occurred in February. Production by Itogon Mining, the third largest producer in the Benguet district, shows increase in recent months; for May, 1932, a recovery of $53,773, or $8.78½ per ton, was made from the treatment of 6,120 tons of ore.



Crossley producer-gas plant, Globe & Phoenix gold mine, Southern Rhodesia

AUSTRALASIA

Gold Activity Unabated. The Queensland gold yield for the first five months of 1932 was 4,484 oz., an increase of 1,207 oz. over the record for the corresponding period of last year. At Mount Coolon, where a 200-ton milling plant is being erected, operations have been delayed, and the plant will not be ready before December, instead of early in September, as originally planned. In Western Australia, the May yield rose to 53,928 oz., which is 15,672 oz. greater than that for May, 1931. For the first five months of 1932, the Western Australian output was 236,000 oz., or 58,000 oz. more than the corresponding period of 1931. The 1932 output in Western Australia should exceed 600,000 oz. . . . Lake View & Star, Kalgoorlie, Western Australia, increased tonnage to 40,000 tons monthly, in July. Electric locomotives have been installed on the main haulage levels. The mill, on the Chaffer's Lease, has five 250-ton Ruwolt ball mills, nine Fahrenwald flotation units, and concentrate-handling equipment. As at Wiluna, the flotation concentrate will be roasted and cyanided. Oliver filters will dewater the concentrate and drying will be done in Lowden machines; Edwards furnaces will be used for roasting; the gold will be precipitated from the cyanide solution by the Merrill-Crowe process. The old milling plant will be used for re-treating accumulated and slime tailings, from which a substantial profit is expected to result. . . . The 250-ton per day bromo-cyanide plant being erected by Boulder Perseverance was completed last month. Great Boulder is considering erection of a new plant at a cost of £80,000, but will await comparison of the Lake View & Star flotation and Boulder Perseverance bromo-cyanide methods before making a decision. With a capital of £45,000, Big Blow Gold has been formed to acquire and equip the Big Blow gold mine, at Coolgardie. It is estimated that 200,000 tons of ore exist to the 100-ft. level, and a similar quantity is expected per 100 ft. of sinking. A 200-ton milling plant is to be erected. The cost of mining and milling is given as 10/ per ton, plus 3/ for development. . . . Mount Coolon Extended has acquired three leases at Mount Coolon, Queensland. Ore reserves to a depth of 300 ft. are estimated at 119,000 tons, assaying 20 dwt. per ton. . . . Activity in gold mining in the Bendigo district continues. For the first five months of 1932, production, 6,132 oz., compared with 5,388 oz. for the corresponding period of last year. . . . Mount Isa (Queensland) treated 42,794 tons of ore during May, for a return of 3,600 tons of bullion assaying 99 per cent lead and 46.7 oz. silver per ton, from 8,621 tons of concentrate. The new D. & L. equipment and the third blast furnace are now in commission, permitting production of 6,000 tons of bullion monthly. . . . Ore reserves of the Mount Morgan mine, Queensland, total 8,000,000 tons, assaying 4.37 dwt. gold and 1.72 per cent copper. In the upper levels are 664,000 tons, assaying 6.52 dwt. gold and 0.91 per cent copper, which can be mined cheaply by open cutting. At the present price of gold this ore can be treated profitably. The Federal Government has made available £15,000 for repairing and re-equipping the plant and for research and plant trials, on the results of which further development depends. . . . Zinc Corporation (Broken Hill, N.S.W.), which made a profit of £108,441 in 1931, recently commenced operations after fifteen months of idleness. . . . Guinea Airways, controlling the air service between the coast of New Guinea and the gold fields at Wau, reports a profit of £28,725 for the year ended Feb. 28, 1932. During the past four years the company's machines have flown 870,000 air-miles, making nearly 6,000 return flights. The cargo carried was over 6,500 tons, or at the rate of 135 tons per month. This tonnage takes no account of the shipment by air of two 10-cu.ft., all-electric bucket dredges and hydro-electric equipment transported in Junker planes purchased by Bulolo Gold. The company has reduced freight charges from 1/- per pound when operations began, to the present figure of 4d. Recently the company established a regular air service from Port Moresby, New Guinea, to the gold fields. Engineers can now visit the field and return to Australia within a fortnight.

MADAGASCAR

Graphite Industry Curtails. Madagascar exported only 6,287 metric tons of graphite in 1931, the lowest since 1920, according to a U. S. Department of Commerce report. A decrease of 32 per cent in the volume of exports, as compared with those of 1930, was accompanied by a decline of 48 per cent in valuation. The island made its record in 1917, when 27,838 tons was exported to England and France. In 1931 the production was only 4,687 tons, and many of the mines were closed down, as a result of lack of demand from Europe and the United States; and prices obtained were below cost of production. Shipments to the United States fell from 1,236 tons in 1930 to 376 in 1931. The largest amount exported went to England; but, with the exception of Germany, where imports rose from 678 tons in 1930 to 1,977 in 1931, all countries are taking less Madagascar graphite than previously.

AFRICA

Developments on the Rand. A large area to the south of Daggafontein, of 2,470 claims, has been leased by the government to Rand Selection Corporation. A new company will be formed, East Daggafontein Mines; and arrangements have been made with Daggafontein Mines whereby that company will use its No. 1 Shaft for development work. Daggafontein Mines will receive 100,000 shares in the new lease company, with the right to subscribe to future issues. . . . Vogelstruisbult Gold Mining Areas has acquired 1,000 claims along the southern boundary of Daggafontein, and 880 claims upon Grootfontein No. 152, the tender for which, by New Consolidated Gold Fields, has been accepted by the government. The new company will acquire 4,405 claims from Rand Mines, and New Consolidated Gold Fields. This ground will probably be developed from Daggafontein Mines No. 2 workings. This will take several years, and milling operations will begin at some date considerably later than at East Daggafontein Mines. . . . The ground acquired by Sub Nigel comprises 2,027 claims, making a total now held of 6,422 claims. Development can be conveniently extended from existing workings, although milling is not possible in the near future.

Rhodesian Copper Developments. Roan Antelope milled 82,600 short tons of 3.71 per cent ore in June; smelter output was 2,089 long tons of blister copper, 99.68 per cent fine. This product, now being fire-refined in England, compares with the best grade of Lake Copper. Demand exceeds output. . . . Three crosscuts in the Roan Antelope mine on Level 620, and two on Level 820, have shown the bed to be 3 ft. to 4½ ft. wider than was calculated from drilling results in the immediate vicinity,

and the average grade is at least 0.25 per cent higher. . . . During the three months ended June 30, Rhokana's cost of landing blister copper at European points, with only about 25 per cent of the plant in operation, disregarding interest and depreciation, was £25.92 per long ton, equivalent, at $3.55 to £1, to 4.1c. per pound. Monthly operating results compare as follows:

1932	Ore Milled Short Tons	Grade, Copper, Per Cent	Blister Output, Short Tons	Copper Shipped, Short Tons
Jan....	48,104	4.15	....	....
Feb....	68,857	4.32	....	....
March.	85,506	5.00	933	777
April...	89,745	4.90	5,002	4,813
May...	106,700	4.97	5,758	5,650
June...	86,161	5.12	6,134	5,832

Vanadium Stocks Accumulate. Rhodesian Broken Hill produced 202 tons of fused vanadium oxide and 602 tons of vanadium concentrate during the first six months of 1932, comparing with 100 tons of vanadium oxide in the same period last year. The vanadium plant is being run at capacity to keep costs low; and by the end of 1932, or not later than the end of January, 1933, sufficient should have been produced to supply all present contracts for next year. This year's production is estimated between 380 and 400 tons of vanadium oxide and about 1,200 tons of concentrate. . . . Tanganyika Concessions, which earned a greater profit in 1931 than in 1930, reports that work at the Kilembe copper mine, in Uganda, continues to show good development. Tanganyika Concessions and Zambesia Exploring have taken an option to acquire an interest in a new gold field over which Eldoret Mining holds extensive prospecting rights in Kenya Colony.

Prospecting Results Disappoint. Loangwa Concessions, Northern Rhodesia, reports that it has prospected 68,732 sq.mi. of its concession area of 134,000 sq.mi.; 33,000 sq.mi. of the remainder consists of swamps and areas which, because of geological formation, are not considered worth prospecting, and 10,000 sq.mi. of Karroo formation unlikely to contain anything except coal. About 22,000 sq.mi. remains to be prospected. Of the discoveries made, of gold, copper, manganese, high-grade iron, kaolin, graphite and barytes, nearly all are considered of no commercial value, none of the copper deposits being important. Two gold discoveries give promise and are receiving further investigation, and two graphite deposits are yielding excellent results, trenches disclosing widths of 6, 9, 11, and 36 ft., with averages of 30, 22, 24, and 18 per cent carbon, respectively. "On the whole," Sir Edmund Davis says, "the results from the detailed examination of the 68,732 sq.mi. within the concession have been disappointing."

Gold Developments in Rhodesia. The "trek" to the alluvial deposits on the Ngesi and Lundi rivers is assuming the dimensions of a gold rush; 100 prospectors are camped at the junction of the two rivers, 32 miles from Shabani, and claims have been pegged over a distance of 12 miles. . . . The Government of Southern Rhodesia has adopted a proposal of the Unemployment Committee whereby parties of ten men apiece, experienced prospectors, are to be sent to areas northeast of Shamva, selected by the government mining engineer. Equipment and rations will be provided, and the men will receive 2s. daily. If payable reef is discovered the rights will be transferred to the party. Ten youths are also to be engaged as "prospector learners." Clothing and rations will be supplied, and they will be paid 10s. a month.

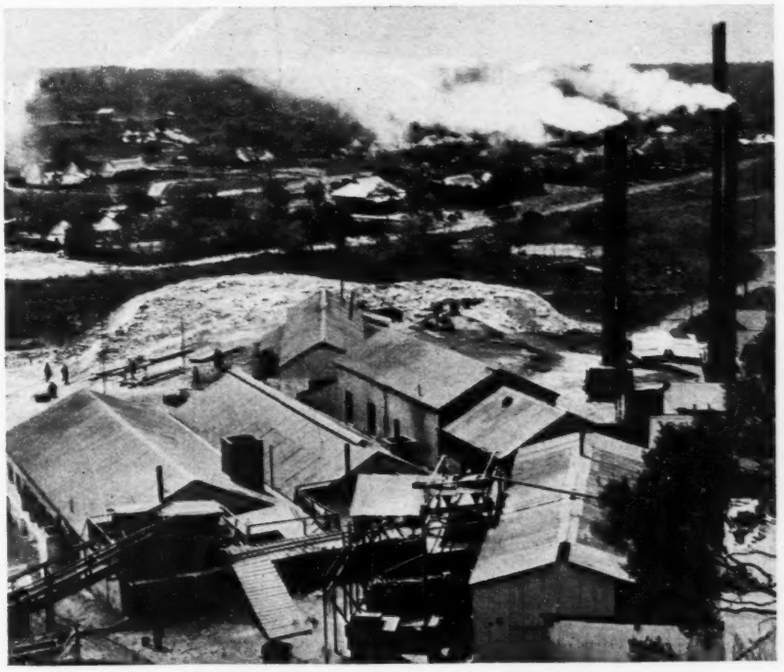
Tin Discoveries in Belgian Congo. Cie. du Kiva announces important tin discoveries in Ruanda, a part of German East Africa mandated to Belgium. The company is shortly to create a subsidiary, Société Minière de Muhinga et de Kigali (Somuki). Even at current tin quotations, the working of these mines is expected to be remunerative. As a result of this discovery and of the other discoveries in the eastern Belgian Congo, extension of the Kenya & Uganda Railway—connecting Mombasa with Lake Victoria — to the Congo border is being urged.

Union Minière Developments. On June 22, Union Minière commemorated the 21st anniversary of the production of its first copper ingot (at the Lubumbashi smelters). From that day to Dec. 31, 1931, the company has produced 1,133,087 tons of copper. . . . To complete the Lobito harbor (Portuguese West Africa terminus of the Benguella Railway, the shortest route to the Katanga and to the mines of Northern Rhodesia), the Portuguese Government has granted an additional sum of 48,000 contos. . . . The Belgian Government recently took action against the Compagnie du Katanga in regard to the ownership of rivers not navigable, by boats or rafts, in its concession. Arbitration has settled this dispute in favor of the Compagnie du Katanga. The company thereupon declined to accept the rights involved, in compensation for which the government has granted to the company an exclusive prospecting right over 70,400 square kilometers in Southern Katanga. The Compagnie Katanga will form the Société de Recherches Minières du Sud Katanga, to develop this area. Union Minière will hand to the new company the discoveries it made in this part of Katanga, which is outside its own concession. In exchange it will get fully paid shares of the new company for a nominal amount of 7,500,000 francs and will be allowed to subscribe for more shares. . . . In the first six months of 1932 the gold output of Kilo-Moto Gold Mines amounted to 2,939 kilos, against 2,464 kilos in the corresponding period of 1931.

EUROPE

Nitrate Agreement Reached. The International Nitrate Conference has concluded a quota agreement satisfactory to the Chilean delegates, according to advices from Paris. The German delegates have returned to Berlin, where an agreement, effective for a year, probably will be signed. The agreement has met with severe criticism in the United States from those who observe that it was consummated with the cooperaion of American inerests in Chilean nitrate, but who maintain that it will operate to the disadvantage of American interests with heavy investments in the domestic synthetic nitrate industry.

Italian Government Subsidizes Mines. The Societa de Monteponi, operating lead and zinc mines in Sardinia, is mining only the richest deposits, and exporting no ore. The Italian Government is paying a subsidy to mines in operation, according to the number of men on the payroll.



Sherwood Star Gold Mines, Southern Rhodesia, where plant capacity is being increased by additional stamp- and tube-mill equipment, and power supply augmented by erection of a 600-hp. gas engine

Daily and Average Monthly Prices of Metals

July, 1932

United States Market

July	Electrolytic Copper: Domestic Refinery	Electrolytic Copper: Export Refinery	Straits Tin: New York	Lead: New York	Lead: St. Louis	Zinc: St. Louis
1	5.150	4.700	20.500	2.750@2.950	2.600@2.800	2.600@2.700
2	5.025@5.150	4.650	20.500	2.750@2.900	2.600@2.750	2.600@2.650
4	Holiday	4.650	Holiday			
5	5.025	4.650	20.375	2.750@2.850	2.600@2.700	2.600@2.650
6	5.150	4.650	20.850	2.750@2.850	2.600@2.700	2.600@2.650
7	5.150	4.650	21.250	2.750@2.850	2.600@2.725	2.600
8	5.025@5.150	4.600@4.650	21.250	2.750@2.800	2.600@2.700	2.600
9	5.025@5.150	4.600@4.650	21.200	2.750@2.800	2.600@2.700	2.550@2.600
11	5.025@5.150	4.600@4.650	20.700	2.700	2.550	2.550
12	5.025@5.150	4.600@4.650	21.100	2.700	2.550	2.550
13	5.025	4.600@4.650	21.000	2.700	2.550	2.550
14	5.025	4.525	21.200	2.700	2.550	2.500
15	5.025	4.475	21.000	2.700	2.550	2.500
16	5.025	4.400	21.000	2.700	2.550	2.500
18	5.025	4.425	20.800	2.650	2.500	2.500
19	5.025	4.350	20.750	2.650	2.500	2.500
20	5.025	4.275	20.875	2.650	2.500	2.500
21	5.025	4.250	20.850	2.650	2.500	2.500
22	5.025	4.200	20.800	2.650	2.500	2.500
23	5.025	4.200	20.750	2.650	2.500	2.500
25	5.025	4.150	20.650	2.650	2.500@2.550	2.500
26	5.025	4.150	20.800	2.650	2.500@2.600	2.500
27	5.025	4.150	21.050	2.800	2.700	2.500
28	5.025	4.350	21.150	2.950	2.850	2.450@2.500
29	5.025	4.350	21.375	2.950	2.850	2.500
30	5.025	4.450	21.500	2.950	2.850	2.500
Av. for Month	5.053	4.453	20.931	2.747	2.611	2.537
July			Averages for Week			
6	5.113	4.700	20.515	2.825	2.705	2.645
13	5.088	4.629	21.083	2.742	2.602	2.571
20	5.025	4.408	20.938	2.675	2.525	2.500
27	5.025	4.183	20.817	2.675	2.546	2.500
July			Calendar Week Averages			
2	5.140	4.950	19.858	2.917	2.813	2.679
9	5.100	4.642	20.985	2.790	2.653	2.605
16	5.046	4.546	21.000	2.700	2.550	2.525
23	5.025	4.283	20.804	2.650	2.500	2.500
30	5.025	4.267	21.088	2.825	2.721	2.496

Silver, Gold, and Sterling Exchange New York and London

July	Sterling Exchange: "Checks"	Sterling Exchange: "90-Day Demand"	Silver: New York	Silver: London	Gold: London
1	3.57	3.57⅝	26¾	16 11/16	115s
2	3.57⅜	3.58	26⅜	16⅜	.....
4	Holiday	Holiday	Holiday	16⅝	116s
5	3.54½	3.55⅛	26⅛	16⅝	116s 5d
6	3.55½	3.56⅜	26⅛	16 1/16	116s
7	3.56½	3.57½	26⅜	16¾	115s 8d
9	3.57¾	3.58⅝	26½	16¾	115s 7d
9	3.57¼	3.58⅛	26⅝	16 11/16	.....
11	3.55⅜	3.56½	26⅜	17 1/16	115s 7d
12	3.55¼	3.55¾	26¾	17	115s11d
13	3.54½	3.55	26⅝	16 11/16	116s 1d
14	3.54½	3.55	26⅞	17	116s 2d
15	3.54⅛	3.54⅞	27	17¼	116s 3d
16	3.54	3.54½	26⅞	17 1/16	.....
18	3.54¾	3.55⅜	26⅞	17	116s
19	3.55⅜	3.56	26¾	16⅞	115s 8d
20	3.56½	3.57	26¾	16⅞	115s 7d
21	3.55⅞	3.56⅜	27	17	115s 5d
22	3.54¾	3.55⅜	26¾	16 11/16	115s11d
23	3.55⅛	3.55¾	26⅞	17 1/16	.....
25	3.55¼	3.55⅝	27	17	115s 9d
26	3.54⅝	3.55¼	27	17⅛	115s10d
27	3.53½	3.54½	26¾	17 1/16	116s 4d
28	3.51¼	3.51⅞	26¾	17⅛	116s 7d
29	3.49¾	3.50¼	26¾	17 1/16	117s 8d
30	3.50½	3.51	26¾	17 1/16	.....
Av. for Month	354.865	.....	26.700	16.930	.....
July		Averages for Week			
6	3.56850	.....	26.325	.....	.....
13	3.56188	.....	26.625	.....	.....
20	3.54917	.....	26.854	.....	.....
27	3.54854	.....	26.896	.....	.....

Calendar week averages: New York Silver, July 2nd, 26.604c. 9th, 26.350; 16th 26.833; 23rd, 26.833; 30th, 26.833.

London Market

July	Copper: Standard Spot	Copper: Standard 3 Mo.	Copper: Electrolytic (Bid)	Tin: Spot	Tin: 3 Mo.	Lead: Spot	Lead: 3 Mo.	Zinc: Spot	Zinc: 3 Mo.
1.....	25.6250	25.2500	29.50	123.750	125.250	9.6875	10.0625	11.4375	11.8750
4.....	26.3750	25.6250	30.50	121.500	123.250	10.0000	10.3750	11.4375	11.9375
5.....	27.1250	26.4375	30.50	123.625	125.375	10.2500	10.6875	11.7500	12.3125
6.....	27.2500	26.7500	30.50	124.000	125.250	10.0000	10.4375	11.6875	12.2500
7.....	27.1250	26.7500	31.00	127.500	128.750	10.0625	10.5000	11.5625	12.0625
8.....	26.9375	26.5625	30.00	126.500	128.250	10.0625	10.5625	11.8125	12.3750
11.....	26.8750	26.3750	30.50	124.750	126.250	10.2500	10.7500	11.5625	12.0625
12.....	26.6250	26.3750	30.50	125.750	127.500	10.1875	10.6250	11.5625	12.0625
13.....	26.3750	25.8750	29.50	126.625	128.000	9.8125	10.1875	11.3750	11.8750
14.....	26.3750	25.8125	29.50	127.875	129.500	9.8125	10.1875	11.3125	11.8125
15.....	26.0000	25.5625	29.00	127.750	129.250	9.6250	10.0000	11.3125	11.8125
18.....	25.6250	25.2500	28.50	127.000	128.750	9.4375	9.8125	11.1875	11.6250
19.....	25.5625	25.1875	28.50	125.750	127.625	9.3750	9.7500	11.2500	11.6250
20.....	25.3750	24.9375	27.75	123.500	125.625	9.2500	9.6250	11.4375	11.7500
21.....	25.2500	24.8750	27.50	125.500	127.375	9.5625	9.8125	11.5625	11.8125
22.....	25.3750	25.0625	27.50	124.750	126.750	9.6250	9.8750	11.5625	11.8125
25.....	25.0000	24.5000	27.50	124.250	126.000	9.6250	9.8125	11.6250	11.8125
26.....	25.0000	24.5625	27.50	125.625	127.250	9.6250	9.7500	11.7500	11.8125
27.....	25.1250	24.7500	27.50	127.000	128.500	9.6875	9.8125	11.8750	11.9375
28.....	26.1250	25.7500	28.75	129.125	130.625	10.0000	10.1875	12.1250	12.2500
29.....	26.3750	26.0000	29.25	131.000	132.500	10.2500	10.3750	12.2500	12.4375
Average for month.	26.071	.....	29.107	125.863	.....	9.818	10.152	11.592	11.967

The United States quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices of domestic class are in cents per pound.

Copper, lead and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted at 0.35c. per pound above St. Louis, this being the freight differential. Contract prices for High-Grade zinc delivered in the East and Middle West are 1c. above St. Louis

Silver and Sterling Exchange

	New York		London Spot		Sterling Exchange	
	1931	1932	1931	1932	1931	1932
January	29.423	29.780	13.810	19.623	485.260	342.515
February	26.773	30.136	12.432	19.573	485.551	345.141
March	29.192	29.810	13.524	18.336	485.596	363.463
April	28.279	28.298	13.120	16.923	485.764	374.731
May	27.650	27.755	12.858	16.868	486.188	367.370
June	27.250	27.466	12.707	16.844	486.291	364.471
July	28.255	26.700	13.197	16.930	485.349	354.865
August	27.524	.....	12.815	.....	485.284	.....
September	28.180	.....	14.101	.....	451.245	.....
October	29.538	.....	17.153	.....	388.029	.....
November	32.223	.....	19.393	.....	371.130	.....
December	30.120	.....	20.023	.....	336.798	.....
Year	28.700	.....	14.594	.....	452.707	.....

New York quotations, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper *(a)*

	F.O.B. Refinery Electrolytic		London Spot Standard		London Spot Electrolytic	
	1931	1932	1931	1932	1931	1932
January	9.838	7.060	44.938	39.459	47.524	46.200
February	9.724	5.965	45.372	36.917	47.950	41.381
March	9.854	5.763	44.818	33.039	47.699	36.786
April	9.392	5.565	42.694	29.943	45.375	34.190
May	8.665	5.237	38.897	28.548	42.175	32.833
June	8.025	5.145	35.827	26.872	38.966	30.841
July	7.698	5.053	34.402	26.071	37.293	29.107
August	7.292	.....	32.572	.....	35.388	.....
September	6.988	.....	31.503	.....	36.148	.....
October	6.775	.....	34.957	.....	41.000	.....
November	6.558	.....	35.854	.....	41.190	.....
December	6.580	.....	38.273	.....	44.409	.....
Year	8.116	.....	38.342	.....	42.093	.....

New York quotations, cents per pound. London, pounds sterling per long ton.
(*a*) Export copper, f.o.b. refinery: Average for July, 4.453.

Lead

	New York		St. Louis		London			
	1931	1932	1931	1932	1931 Spot	1931 3 Mos.	1932 Spot	1932 3 Mos.
January	4.802	3.750	4.604	3.550	13.872	13.905	15.084	15.128
February	4.552	3.712	4.340	3.499	13.444	13.550	14.560	14.571
March	4.527	3.150	4.276	2.993	13.128	13.355	12.345	12.634
April	4.412	3.000	4.164	2.900	12.375	12.606	11.223	11.503
May	3.818	3.000	3.651	2.900	11.491	11.778	10.673	11.036
June	3.917	2.993	3.761	2.896	11.582	11.952	9.608	9.898
July	4.400	2.747	4.225	2.611	12.731	12.899	9.818	10.152
August	4.400	.....	4.225	.....	11.944	11.994	.....	.....
September	4.400	.....	4.217	.....	11.932	12.026	.....	.....
October	3.964	.....	3.773	.....	13.227	13.270	.....	.....
November	3.937	.....	3.758	.....	14.577	14.491	.....	.....
December	3.792	.....	3.592	.....	15.188	15.361	.....	.....
Year	4.243	.....	4.049	.....	12.958	13.099	.....	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin

	New York		London	
	1931	1932	1931	1932
	Straits		Spot	
January	26.137	21.804	115.798	140.219
February	26.315	22.018	117.919	139.143
March	27.065	21.863	121.852	129.810
April	25.222	19.244	112.775	108.935
May	23.221	20.948	104.331	122.286
June	23.478	19.659	104.966	114.530
July	24.978	20.931	111.478	125.863
August	25.738	.....	114.875	.....
September	24.618	.....	117.813	.....
October	22.723	.....	126.932	.....
November	22.779	.....	132.857	.....
December	21.328	.....	138.909	.....
Year	24.467	.....	118.375	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St. Louis		London			
	1931	1932	1931 Spot	1931 3 Mos.	1932 Spot	1932 3 Mos
January	4.035	3.011	12.747	13.113	14.416	14.834
February	4.012	2.817	12.303	12.694	13.872	14.289
March	4.002	2.787	12.190	12.676	12.616	13.024
April	3.717	2.725	11.353	11.838	11.670	11.958
May	3.306	2.532	10.484	10.875	12.432	12.682
June	3.416	2.777	11.270	11.750	11.548	11.866
July	3.893	2.537	12.280	12.802	11.592	11.967
August	3 917	.....	11.444	12.028	.....	.....
September	3.744	.....	11.571	12.063	.....	.....
October	3.377	.....	12.733	13.216	.....	.....
November	3 209	.....	13.845	14.247	.....	.....
December	3.149	.....	14.361	14.818	.....	.....
Year	3.640	.....	12.215	12.677	.....	.....

St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Cadmium and Aluminum

	Cadmium		Aluminum	
	1931	1932	1931	1932
January	67.115	55.000	23.300	23.300
February	55.000	55.000	23.300	23.300
March	55.000	55.000	23.300	23.300
April	55.000	55.000	23.300	23.300
May	55.000	55.000	23.300	23.300
June	55.000	55.000	23.300	23.300
July	55.000	55.000	23.300	23.300
August	55.000	.....	23.300	.....
September	55.000	.....	23.300	.....
October	55.000	.....	23.300	.....
November	55.000	.....	23.300	.....
December	55.000	.....	23.300	.....
Year	56.010	.....	23.300	.....

Aluminum in cents per pound, 99 per cent grade.
Cadmium, cents per pound.

Antimony, Quicksilver, and Platinum

	Antimony (*a*) New York		Quicksilver (*b*) New York		Platinum (*c*) New York	
	1931	1932	1931	1932	1931	1932
January	7.317	5.976	103.000	64.900	36.000	40.000
February	7.069	6.489	100.205	66.304	34.000	40.000
March	7.127	6.188	100.423	72.537	29.538	40.000
April	6.888	5.746	102.077	72.125	26.346	40.000
May	6.524	5.170	101.140	66.380	24.980	39.500
June	6.342	5.034	92.058	59.481	37.115	37.500
July	6.802	5.000	85.808	53.580	40.000	35.200
August	6.596	.....	80.115	.....	40.000	.....
September	6.542	.....	76.300	.....	40.000	.....
October	6.517	.....	72.385	.....	40.000	.....
November	6.679	.....	68.587	.....	40.000	.....
December	6.231	.....	66.115	.....	40.000	.....
Year	6.720	.....	87.351	.....	35.665	.....

(*a*) Antimony quotations in cents per pound, for ordinary brands. (*b*) Quicksilver in dollars per flask of 76 lb. (*c*) Platinum in dollars per ounce troy.

Pig Iron[1]

	Bessemer		Basic		No. 2 Foundry	
	1931	1932	1931	1932	1931	1932
January	17.50	16.00	17.00	15.00	17.00	15.50
February	17.29	15.68	16.79	14.68	16.79	15.18
March	17.00	15.50	16.50	14.50	16.50	15.00
April	17.00	15.50	16.50	14.50	16.50	15.00
May	17.00	15.50	16.38	14.50	16.44	15.00
June	17.00	14.85	15.50	14.35	16.00	14.75
July	17.00	14.56	15.50	14.00	16.00	14.50
August	17.00	.....	15.50	.....	16.00	.....
September	17.00	.....	15.50	.....	16.00	.....
October	16.92	.....	15.42	.....	16.00	.....
November	16.50	.....	15.00	.....	16.00	.....
December	16.25	.....	15.00	.....	15.75	.....
Year	16.96	.....	15.88	.....	16.25	.....

Iron in dollars per long ton. [1]F.o.b. Mahoning and Shenango Valley furnaces; freight to Pittsburgh, $1.76.

prices for the Prime Western grade.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

London prices for lead and zinc are the official prices for the morning session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

New York silver quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, 925 fine. Sterling prices represent forenoon market demand. Cables command a premium.

Current Statistics of Production and Stocks of Copper, Lead, and Zinc

Data from American Bureau of Metal Statistics, American Zinc Institute, and Metallgesellschaft.

All Figures Except Tin Represent Tons of 2,000 Lb.

	1931						1932					
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
COPPER — North and South America												
Production, refined, daily average	3,110	2,909	2,890	2,918	2,693	2,780	.....	.....	.....	.....	.....	.....
Domestic shipments	43,144	45,816	40,459	51,348	37,436	36,972	.....	.....	.....	.....	.....	.....
Foreign shipments	26,321	29,016	22,124	21,030	20,257	26,032	.....	.....	.....	.....	.....	.....
Stocks, blister and refined	620,075	631,880	658,321	.....	.....	722,014	.....	.....	.....	.....	.....	.....
LEAD — United States												
Production, refined, from domestic ore	32,157	34,144	31,966	36,546	31,671	33,576	32,180	28,081	30,345	23,236	25,902	26,068
Production, secondary and foreign	4,409	5,453	3,934	4,722	3,820	4,031	3,554	3,920	3,989	3,134	2,941	2,033
Production, total, daily rate	1,179	1,151	1,163	1,331	1,180	1,213	1,185	1,103	1,107	879	930	936
Shipments reported	42,219	38,590	34,059	34,276	31,216	30,297	27,867	26,319	31,162	26,081	24,258	21,511
Stocks, end of month	133,958	134,977	132,804	139,796	144,057	151,380	160,257	165,933	169,091	169,091	173,929	180,460
ZINC — United States												
Production, daily average	689	692	712	699	684	709	723	742	726	688	601	547
Domestic shipments	28,460	23,599	20,902	21,163	20,327	21,005	22,472	21,896	22,576	18,046	18,087	14 958
Export shipments	20						31					
Stocks, end of month	131,833	129,701	130,155	130,666	130,865	129,825	129,886	129,506	129,451	132,025	132,580	134,032
World Production Rate (Daily Average)												
Copper	3,919	3,924	4 023	3,940	4,070	3,940	.....	.....	.....	.....	.....	.....
Lead	3,691	3,906	3,654	3,806	3,980	3,976	3,938	3,872	3,598	3,596	3,711	3,491
Zinc	2,860	2,766	2,814	2,736	2,725	2,601	2,600	2,615	2,623	2,528	2,392	2,343
Tin (Metric Tons)	401	416	349	352	325	351	311	274	340	309	287	.....

Complete Market News and Prices

THE monthly magazine you are now reading carries only a condensed statistical summary of prices of the major metals. For buyers and sellers of ores, metals, minerals, and scrap who require reliable information as soon as it is available, we now provide *Metal and Mineral Markets,* which goes to press at the close of the metal-market week each Wednesday. It is printed at high speed and is in the mails that evening. In compact form, ready for insertion in a ring binder, it is ideal for desk and reference use. It carries the standard *E.&M.J.* quotations used in contracts the world over, recognized as authoritative and dependable. *Metal and Mineral Markets* is priced to subscribers in the United States and its possessions at $3 per annum; to countries in the Americas but outside the United States, $6; elsewhere, $10 yearly: 52 issues. Address *M.&M.M.*, 330 West 42d St., New York City.

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